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Status of three Wolfish species (*Anarhichus lupus, A. minor* and *A. denticulatus*) in Newfoundland waters (NAFO Divisions 2GHJ3KLNOP)

État des stocks de trois espèces de loup de mer (*Anarhichus lupus, A. minor* et *A. denticulatus*) dans les eaux terre-neuviennes (divisions 2GHJ3KLNOP de l'OPANO)

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ABSTRACT

With the decline in the "traditional" groundfish resources in the waters around Newfoundland, interest in the exploitation of alternate species increased in the early 1990's. Two species of wolffish (*A. lupus* and *A. minor*), which inhabit Newfoundland waters, and are common as bycatch in other directed ground fisheries were considered as potential candidates for new or expanded fisheries. However, wolffish were not found in found in sufficiently dense concentrations to sustain a directed fishery. In the late 1990's, due to observed declines in both the numbers and weights, *A. minor* and *A. denticulatus* have been designated by COSEWIC as "threatened". *A. lupus* was listed as a "Species of Concern". This paper provides an examination of available information on distributions, trends in abundance and biomass from research vessel survey data, and recent history of the commercial landings of spotted, striped and northern wolffish. All three species declined in abundance during the 1980's and have remained low since. Reduction in extent of distribution as well as abundance was much greater north of 48^{0}N (northeast Newfoundland and Labrador Shelves. South of 48^{o}N (Grand Banks) reductions were minimal (perhaps even a slight increase for striped wolffish). Since the mid-1990's the abundance of all three species has been stable or increasing in the case of spotted and striped wolffish.

RÉSUMÉ

Au début des années 1990, le déclin des ressources « traditionnelles » en poisson de fond dans les eaux entourant Terre-Neuve a entraîné un intérêt accru pour l'exploitation d'autres espèces. Ainsi, on estimait que deux espèces de loup de mer (*A. lupus* et *A. minor*), qui vivent dans les eaux terre-neuviennes et sont souvent capturées accidentellement dans des pêches dirigées d'autres poissons de fond, pourraient faire l'objet de pêches nouvelles ou élargies. Toutefois, on n'a pas trouvé de loup de mer en concentrations suffisantes pour soutenir une pêche dirigée. À la fin des années 1990, le COSEPAC a désigné *A. minor* et *A. denticulatus* comme espèces « menacées » en raison des baisses observées de leur abondance et de leur poids corporel. *A. lupus* a été désignée « espèce préoccupante ». Dans ce document, nous examinons les données disponibles sur la répartition, l'évolution de l'abondance et de la biomasse (données de relevés de navire de recherche) et l'historique récente des débarquements commerciaux du loup tacheté, du loup atlantique et du loup à tête large. L'abondance des trois espèces a baissé au cours des années 1980 et elle est restée faible depuis. Les réductions de l'aire de répartition et de l'abondance ont été beaucoup plus fortes au nord de 480N (plates-formes du nord-est de Terre-Neuve et du Labrador) qu'au sud de cette latitude (Grands Bancs), où les réductions ont été minimales (le loup atlantique y a peut-être même connu une légère hausse). Depuis le milieu des années 1990, les effectifs du loup tacheté et du loup atlantique ont augmenté, tandis que l'abondance du loup à tête large s'est stabilisée.

INTRODUCTION

Wolffish (family Anarhichadidae) are elongated fish inhabiting a wide range of northern latitudes and depths in the Atlantic and Pacific Oceans (Scott and Scott 1988). They are named for their large, powerful jaws and canine-like teeth used to crush various invertebrate prey (Rodriguez Marin *et al.* 1994, Al'bikovskaya 1983). The family is sometimes referred as catfish particularly by the fishing industry.

Four species of the genus *Anarhichas* commonly inhabit Canadian waters, *A. lupus*, (Atlantic or striped wolffish), *A. minor* (spotted wolffish), *A. denticulatus* (northern or broadhead wolffish), in the Atlantic and Arctic Oceans (Barsukov 1959, Templeman 1985, 1986b) and *A. orientalis*, the Bering wolffish in the Arctic Ocean (Houston and McAllister 1990). *A. lupus, minor* and *denticulatus* are also distributed in the northeastern Atlantic (Barsukov 1959, Baranenkova, et al., 1960). Distinguishing features of the three Atlantic species are: *A. lupus* - grey with vertical bars most of the length of the body, *A. minor* - spotted and darker and *A. denticulatus* - more evenly coloured (dark) with a large thick head, hence the alternate name, broadhead. Templeman (1986b) also described spotted forms of *A. denticulatus*, some of which were previously suggested to be inter-specific forms between *A. lupus*, and *A. minor* (Luhmann 1954).

In the northwest Atlantic, spotted, striped and northern wolffish are distributed from Davis Strait to Maine (Al'bikovskaya 1982). Striped wolffish are generally concentrated further to the south and at shallower depths (100-350 m.) than the other two species and are associated with water temperatures as cold as 0.4°C. Spotted and northern wolffish inhabit deeper waters to beyond 475 m and temperatures of 3.1-4.0°C. Kulka and DeBlois (1996) described the distribution of the three species off Atlantic Canada as quite extensive, inhabiting most of the Labrador and northeast Newfoundland Shelves (less so in recent year) to the southern Grand Banks and Flemish Cap (Fig. 1).Striped wolffish differed from the other two species in that they are densely concentrated on the shallow part of the southern Grand Bank (Kulka and Deblois 1996). McRuer et al. (2000) also showed that striped wolffish was also common in the deeper parts of the Gulf of St. Lawrence and on the Scotian Shelf, mainly to the southwest and in the Bay of Fundy.

Templeman (1984) through tagging studies showed that wolffish underwent limited migration, most recaptures occurred within 8 km of the tagging site. Kohler (1968) and Keats et al. (1985) reported seasonal movement inshore by striped wolffish. The broad distribution observed for the three species coupled with limited movement as suggested by Templeman (1984) suggests the possibility of existence of Evolutionary Significant Units (ESU's) or sub-populations. No work has been carried out to establish whether this is the case.

Based on growth, fecundity and age characteristics as described by Musick (1999), wolffish fall into the "low" productivity category. The testes of these species are relatively small, sperm and egg production is low, fertilization is internal and eggs and larvae are large. Wiseman (1997) reports that newly hatched larvae of striped wolffish are about 2 cm. Although fecundity is low, internal fertilization (Pavlov 1994), nesting habits and egg guarding behaviour (Keats et al. 1985) effectively increases the potential for survival during the early life stages. Striped wolffish in Newfoundland waters spawn in September and the entire larval stage is spent close to the location of hatching

(Templeman 1985 and 1986a). Information on spotted wolffish is more limited, but they appear to spawn in late autumn or early winter.

Details of wolffish life history in Canadian Atlantic waters are sparse, perhaps because it is not the target of a commercial fishery. Templeman (1984, 1985, 1986a, 1986b) and Al'bikovskaya (1982) examined certain aspects of its biology and Kulka and DeBlois (1996) looked at abundance and distribution. More recently, McRuer et al. (2000) examined fish sizes and maturity in addition to abundance and distribution on the Scotian Shelf and in the Gulf of St. Lawrence. However, many knowledge gaps remain. In particular, no age dis-aggregated studies have been done for the northwest Atlantic but age-length relationships are established for the Northeast Atlantic (Shevelev 1995). Natural and fishing mortality in the Barents sea (Shevelev 1992), migration (Riget 1986) and distribution and abundance off West Greenland (Riget and Messtorff 1987, Messtorff, 1986) have been examined. The aquaculture potential of these two species has been examined through egg rearing (Falk-Petersen and Hansen 1994), growth rate (Moksness 1994, Moksness and Stefanussen 1990) and feeding (Orlava *et al.* 1989a, b) experiments.

Wolffish have been exploited in a directed fishery off Greenland (Moller and Ratz 1999, Smidt 1981) but within Canadian waters, it has only ever comprised bycatch. Kulka (1986) reported on levels of bycatch of the three species in Canadian waters. It was noted that annually, during the 1980's, about 1,000 t of the 3 species (combined) were caught in a variety of fisheries directed for other species. About half of the striped and spotted wolffish were landed and all of the northern wolffish were reported as discarded. Information on distribution presented by Kulka and DeBlois (1996) indicate a potential for overlap of fisheries outside 200 miles on the Grand Banks and on the Flemish Cap but data on catches outside 200 miles are not accessible.

With the decline in the Atraditional≅ groundfish resources in the waters around Newfoundland, in the early 1990's, interest in the exploitation of alternate species increased. Striped and spotted wolffish had been considered in the mid 1990's as potential candidates for new directed fisheries. However, experimental fishing did not identify areas where catch rates were sufficiently high to warrant directed commercial exploitation. This finding was consistent with studies that show that wolffish do not form dense concentrations (Templeman 1986a, Kulka and DeBlois 1996).

Kulka and DeBlois (1996) noted a significant decline in the numbers and weights of the three species starting in the late 1970's and early 1980's. Subsequently, two species (striped and spotted wolffish) have been designated by COSEWIC (Committee On The Status Of Endangered Wildlife In Canada, the jurisdictional body responsible for species at risk issues) as "threatened". This designation refers to species likely to become Endangered if limiting factors are not reversed and Endangered refers to species facing imminent extirpation or extinction. The COSEWIC listing report indicated that abundance had declined by over 90% over three generations, extent of distribution had decreased, and that threats included mortality as by-catch in commercial fisheries and habitat alteration by bottom trawling. Theses declines in abundance were concurrent with a widespread reduction in abundance of many groundfish species from the Grand Banks to the northern Labrador Shelf. The third species, striped wolffish was listed as a "species of concern" (particularly sensitive to human activities or natural events but not endangered or threatened). While all three species have undergone a substantial decline during the 1980's-1990's, the proximal cause remains uncertain.

This paper reviews available information on biology, historical catches, biomass and abundance from research vessel surveys and distribution northeast of the Laurentian Channel, from the Grand Banks to the Labrador Shelf (Fig. 1) for striped, spotted and northern wolffish. Information from both research vessel surveys and the commercial fisheries (bycatch) are used to examine changes in abundance and distribution. Distributional patterns observed may also provide some basis for defining management units. Fish size from the commercial catches, where available, are also presented.

METHODS

Research Data

Research trawl surveys, 1971 to date, were used to examine distribution, abundance and sizes of the three wolffish species in the northwest Atlantic. A summary of the stratified-random survey design adopted by the Newfoundland region after 1970 can be found in Doubleday (1981). While survey design has remained constant, additional strata have been included in recent years along with modifications to some of the original strata. An accounting of these modifications can be found in Bishop (1994). Data on the three wolffish species has routinely been collected during these surveys.

It should be noted that a change in the survey gear occurred from an Engels 145 to Campelen 1800 bottom trawl after the spring 1995 survey. Gear conversion factors for amounts and sizes of fish caught were derived for the major species but not for minor species, including wolffish. Thus, the catch rate data and resulting biomass and abundance indices are on a different scale between the spring of 1995 and subsequent surveys. The two periods must be considered as unrelated time series. The change in scale is delineated on the various tables and figures.

Trawl data from both fall (1977-2001) and spring (1971-2001) stratified random surveys were used to estimate biomass and abundance for wolffish in NAFO Divisions 2GHJK3LNOPs, where available, using STRAP (Smith and Somerton 1981). STRAP estimates biomass (and numbers of fish) by areal expansion within each of a series of pre-defined strata added over the survey area.

Distributions were plotted for the fall research vessel surveys using Engels and Campelen sets. Initially, point pattern plots for each fall survey year was plotted using ACON (Black 2001). Following the initial plotting, the data were separated into 3 periods: 1980-1984, 1985-1993 and 1994-2001 based on different patterns of distribution among the three periods. Potential mapping in SPANS was used to map the distribution during those three periods. Potential mapping (Anon 2000) transforms points to fish density surfaces by placing a circle around each point and averaging the values of all points that fall within the circle. The circle size selected (9 km diameter) provided complete coverage of the survey area while minimizing gaps in the density surface and thus maximizing spatial resolution. The study area periphery was isolated using a 'cookie cut' technique (referred to as a basemap cut in SPANS). This resulted in a density surface bounded on all sides by either land, the 1000 m depth contour. The resulting map was then post-stratified into 15 classes defining density of the fish, each covering approximately the same amount of area. Details of the methods are described in Kulka (1998). For potential mapping, three time periods were chosen to correspond with biologically different periods for the wolffish. From 1980-1984, all three wolffish were relatively abundant whereas 1985-1994 was a period of decline in the abundance. The final

period, 1995-2001 represents a period of low but increasing abundance. The strata class bounds (numbers per tow) were held constant across year groups so that varying amounts of each grey shade displayed depicting a density level would reflect relative changes in density over time. In addition, an area of occupancy index was created which calculates the percent area of high, medium and low density areas of wolffish within NAFO Division 2G-3Ps.

Striped and spotted wolffish were measured for total length for most survey sets since 1981. Survey length frequencies were plotted by year from 1981 to 2001. As well, following the calculation of number at length in survey trawls the spatial distribution of large (>55cm) and small (<55cm) striped and spotted wolffish were plotted by year using ACON to detect any size-related variation in spatial distribution. While details of size related sexual maturity of wolffish are limited, females greater than 55cm are generally sexually mature in Newfoundland waters (Templeman 1986).

Fisheries data

Landings of wolffish from bycatch from other fisheries were compiled using statistical records contained within the Zonal Interchange Database (ZIF) for the Canadian fishery. Landings from other countries were compiled from NAFO Table 5 statistics. However, neither source specifies species or accounts for discarded fish and thus these data underestimate removals.

RESULTS

Annual Survey Biomass and Abundance Estimates: STRAP estimates of wolffish biomass and abundance were conducted based on the available fall RV surveys from 1977-2001 and spring RV surveys from 1971-2001 by NAFO Division (Table 1, Figure 2). Abundance and biomass indices for striped (Fig. 2a, Table 1a,b), spotted (Fig. 2b, Table 1c,d) and northern (Fig. 2c, Table 1e,f) wolffish from the fall research vessels demonstrate a significant decline in the estimated numbers and biomass starting in the early 1980's for all three species. Since 1995, all three species have shown some increase in biomass and abundance, particularly striped wolffish, however the magnitude of this increase is not comparable to the early time series due to the change in gear type and lack of a catchability conversion factor (between Engels and Campelen gear). In spring research surveys, biomass and abundance indices for striped (Table 1g,h), spotted (Table 1i,j) and northern (Table 1k,l) wolffish increased during the 1970's, declined during the early 1980's, recovered during the late 1980's and declined during the early 1990's. Since 1996, the spring abundance and biomass indices have increased, however the magnitude of this increase is not comparable to early time periods as indicated above. While fall surveys in the northern NAFO Divisions 2GH have been infrequent, striped (Table 1m), spotted (Table 1n) and northern (Table 1o) wolffish appear to have undergone a similar pattern of decline from the early 1980's to the mid-1990's.

While the decline in abundance and biomass estimates of all three species has occurred throughout Newfoundland waters, based on fall survey data, it appears that the magnitude of decline was greatest in more northern divisions for striped (Fig. 2a, Table 1b) and northern wolffish (Fig. 2c,Table 1f). In both cases the magnitude of decline exhibited in fall research vessel surveys in NAFO Divisions 2J and 3K was greater than that observed in NAFO Division 3L. For spotted wolffish, the greatest decline in fall biomass estimates occurred later than observed in the other

species of wolffish and also occurred mainly in NAFO Division 3L on the northern Grand Banks (Fig. 2b, Table 1d).

For all three species, the spring research vessel survey biomass and abundance indices decline from the late 1980's to mid-1990's, particularly in NAFO Division 3L, the northern most area surveyed in the spring. For spotted wolffish, the large majority of biomass and abundance occurs in NAFO Division 3L (Table 1i,j). Similarly, for northern wolffish (Table 1k,l) the majority of biomass and abundance occurs in NAFO Division 3L, though NAFO Division 3P (St. Pierre Bank) contributes significantly to the population estimates. Unlike spotted and northern wolffish, a significant component of the spring biomass estimate of striped wolffish is concentrated in NAFO Divisions 3NO on the southern Grand Bank (Table 1g).

In recent years there has been a trend of increasing fall survey abundance and biomass indices. Particularly for striped wolffish (Fig. 2a), the numbers of striped wolffish consistently increased from 1995-2000. Furthermore, the biomass of striped wolffish increased throughout the period 1995-2001. These observed increases occurred primarily in NAFO Division 3O and 3L. For spotted wolffish, the number and biomass of spotted wolffish increased during the period 1995-2001 particularly in NAFO Division 3KL (Fig. 2b, Table 1c,d). Unlike the previous two species, northern wolffish populations while increasing from 1995-1999 have recently under gone further reductions. Similar to spotted wolffish, northern wolffish biomass and abundance increased mainly in NAFO Division 3KL until 1999 but since then has been quite variable throughout NAFO Divisions 2J3KLNO.

Associated with the decline in abundance and biomass of striped wolffish from the early 1980's to the mid-1990's, the relative size (total biomass/total number) of striped wolffish also declined in NAFO Divisions 2J3K (Table 2a). Throughout the survey time periods, relatively larger striped wolffish were captured in the southern NAFO Divisions 3NO than in NAFO Division 2J3KL. In the case of striped and spotted (Table 2b) wolffish the relative size of fish is smaller in more recent yeas in all divisions since the change to the Campelen survey gear. For spotted wolffish, the relative size of fish in the northern NAFO Divisions 2J3KL was greater than that in NAFO Divisions 3NO. Unlike striped wolffish, the relative size of northern wolffish (Table 2c) increased during the period 1981-1991 in NAFO Divisions 2J3KL, however declined after that point. Similar to the other species of wolffish, the current relative size of northern wolffish is lower than that previously observed when surveys were conducted with the Engels trawl.

Length Frequencies: While information on the size of northern wolffish are not available, the length frequencies of striped and spotted wolffish captured during research vessel trawls were plotted for the period 1981-2001 (Fig. 3a-f). From 1981 to 1994, there is a decline in the number of fish captured. As well, there is an apparent reduction in the number of large fish (>55cm), of both species captured. For striped wolfish in particular, there has been an increase in the number of small fish captured during the 1995-2001 surveys (Fig. 3d,e,f), and the change to the Campelen survey gear. In addition, while the lower limit of the size of striped wolffish captured has been reduced, there is also an apparent trend towards larger striped wolffish being captured in more recent years as the relative frequency of fish greater than 55cm has increased.

Distribution maps: All three species of wolffish are widely distributed throughout waters off Newfoundland and Labrador. Fall research survey catches, in NAFO Subareas 2 & 3, plotted using scaled point plots show large catches of northern (Fig. 4a-f), striped (Fig. 5a-f) and spotted (Fig. 6a-f) wolffish distributed throughout the Labrador and northeast Newfoundland Shelves to the southern Grand Banks. In years when they are sampled, wolffish are also found on the Flemish Cap and in NAFO regions 2GH. For northern wolffish, large catches occurred throughout NAFO Division 2J3K during the early 1980's (Fig. 4a,b). However, from 1986-2001, the distribution of larger catches of northern wolffish are increasingly limited to the shelf edge throughout the entire survey area. A similar pattern is also apparent in the distribution of striped wolffish. However, in addition to large catches on the shelf and bank edges, striped wolffish are also captured in shallower waters, in particular on the southern Grand Bank (Fig. 5d,e) in NAFO Division 3NO. Similar to the distribution of the northern wolffish, the distribution of catches of spotted wolffish are increasingly limited to the periphery of the Labrador shelf and Grand Bank from 1990-2001 (Fig. 6d,e,f,). Overall, it appears that the distribution of all three species of wolffish has contracted in recent years relative to their distribution during the 1970's and early 1980's. This coincides with an observed decline in the biomass and abundance estimates of these species in the regular research vessel surveys.

Year Group Comparison - Distribution Plots: Aggregate plots of wolffish distributions for the time periods 1980-1984, 1985-1993 and 1994-2001 showed declining distribution in both intensity (lower catch rates) and extent of the distribution of striped (Fig. 7a,b,c), spotted wolffish (Fig. 8,a,b,c) and northern (Fig. 9a,b,c) wolffish.

During the 1980-1984 time period, striped wolffish were widely distributed north of the Grand Bank covering much of the shelf, with a few occurrences along the eastern Grand Bank shelf edge and on the Flemish Cap. A separate aggregation of striped wolffish centred at Lat. 44^0N west of the Southeast Shoal on the tail of the Grand Bank was also apparent and well separated from the concentrations on the Labrador Shelf. During the 1985-1993 and 1994-2001 periods there was an apparent reduction in the extent and intensity of the northern component of striped wolfish (Fig. 7b,c,), however the intensity and extent of the southern component remained relatively unchanged.

Prior to 1986, spotted wolffish was extensively distributed north of the Grand Bank covering much of the shelf, with a few occurrences along the eastern Grand Bank shelf edge and on the Flemish Cap (Fig. 8a). By 1985-93, previously observed areas of high density had disappeared, the distribution was reduced to low density concentrations along the shelf edge and in deep channels(Fig. 8b). During the most recent time period, 1994-2001 there were no concentrations of spotted wolffish compared to previous time periods (Fig. 8c).

Similar to the pattern observed for the northern component of striped wolffish, northern wolffish were widely distributed through out the area north of the Grand Bank covering much of the shelf, the eastern Grand Bank shelf edge and the Flemish Cap during the time period 1980-1984 (Fig. 9a). During 1985-1993, there was a decline in the extent and intensity of the distribution of northern wolffish (Fig. 9b). More recently, northern wolffish are concentrated only on the shelf edge, the edge of the southern Grand Bank and on the Flemish Cap (Fig. 9c).

Young of the year striped wolffish, captured in IYGPT trawls (Table 3) conducted in 1996-1999 (Aug. Sept.) are widely distributed offshore on the Labrador Shelf (Fig. 10). Furthermore, small (<55cm) spotted (Fig. 12a-f) and striped (Fig. 14a-f) wolffish, captured in regular fall research vessel trawl surveys, are found to be distributed in similar offshore areas. Overall, there is considerable overlap in the distribution of catches of small and large (>55cm) spotted (Fig. 11a-f) and striped (Fig. 13a-f) wolffish. For both species, the extent of large catches diminishes from 1981 to 1995 throughout the survey area. In the case of striped wolffish, there is an increase in the size of catches of small fish from 1995 to 2000 along the edge of the northern shelf and on the southern Grand Bank (Fig. 14d,e.f.). For spotted wolffish, there is no apparent significant improvement in the capture of small fish in recent years.

In addition to visual inspection of the distribution of catches, the area of NAFO Divisions 2G-3Ps occupied by all three species was quantified for the high density periods of 1980-1984 relative to the current low density periods, 1995-2001 (Fig. 15). Both the relative and absolute area occupied by high, medium and low density concentrations of all three species declined from the high density periods of 1980-1984 relative to the current low density periods, 1995-2001 (Fig. 15). The decline in the area occupied by high densities of wolffish was most pronounced for the northern wolffish (55%), and least pronounced for striped wolffish (38%). The area occupied by high density Spotted wolffish populations declined by 47%.

Commercial Fisheries: Currently, the catches of wolffish are unregulated. Although, particularly prior to the 1980's, these species have not been targeted for a directed fishery, their extensive distributions have made them a common bycatch in many of the Labrador Shelf and Grand Bank fisheries. Wolffish species are reported in the landing statistics as a single entity, catfish but comprise all 3 species; striped, spotted and northern wolffish, the first two are of commercial value. Northern wolffish is not of commercial value and is discarded. During the 1980's, catches including amounts discarded at sea exceeded 1000 t in most years then declined after 1991 when many groundfish fisheries were closed (Fig. 16a,b). However, Kulka (1986) reported that nearly all northern wolffish were discarded while about half of the two other species were retained and thus landings underestimate the catches. A greater proportion was retained in the 1990's. Reported Canadian landings were only 23 t in 1996, increasing to 157 t in 1997 and 155 t in 1998 and 315 t in 1999 (Table 4). Reported landings for 2000 are 369 t. Recent increases are due mainly to bycatch from the cod fishery in 3Ps. It should also be noted that foreign catches outside the 200 mile limit are underreported.

DISCUSSION

Kulka and DeBlois (1996) found that prior to 1980, restricted sample area from research surveys (poor coverage up to 1976) limited interpretation of trends in density distribution. However, a visual comparison of pre-1980 patterns indicates that distributions were similar to the 1980-1984 period presented in this paper. From 1980 to the present, all three species suffered a constriction in distribution. Annual survey estimates also point to a decline in total abundance and the declines starting in the early 1980's. All species showed declines in size over some part of their distribution from the early eighties to the nineties. The declining catches and sizes noted here for wolffishes agree generally, with other published accounts for these species. Wolffish catches and average size

off West Greenland have declined from 1982 to 1993 (Riget and Messtorff 1987, Ratz 1994).

While the biomass index of northern and spotted wolffish remain at low levels, the index for striped wolffish has increased over the past six years perhaps suggesting some recovery. However, most of the biomass of striped wolffish is located on the southern central Grand Bank. It's biomass remains very low in areas to the north.

Wolffish have been exploited in a directed fishery off Greenland (Moller and Ratz 1999, Smidt 1981) but within Canadian waters, it has only ever comprised bycatch. However, the concentration on the southern Grand Bank is sufficiently dense such that bycatches from the yellowtail fishery to the north overlapping this concentration now yields the majority of the catch of striped wolffish in the Atlantic (Kulka 2002).

Exploitation on both of these species has been low in the 1990's. Currently there is a lack of information on stock and age structure, growth rates and age at maturity of wolffish in the waters around Newfoundland. Under the Species at Risk program, there is an initiative to gather and analyze this basic information.

CONCLUSIONS

There is little consensus in the literature about the proximal cause for declines in fish catches throughout the Northwest Atlantic. Attempts to relate biomass indices to environmental signal have met with little success and overfishing hypotheses are not fully satisfactory in many instances. The latter is especially lacking for non-traditional species since directed fishing on these species has, for the most part, been nonexistent although bycatch mortality could have contributed. This pattern, including an extension of distributional extent to deeper waters has also been observed in some other species (Atkinson, 1994) during the same period. Also, some of the most intense fishing effort during this latter period was located on the shelf edge north of the Grand Bank where much of the northern species in this study and the vestiges of some commercial species ended up. This suggests significant non-fishery influences effecting the distributional and abundance changes.

Based on the degree of decline of the three species, COSEWIC (Committee On The Status Of Endangered Wildlife In Canada) listed northern and spotted wolffish as "threatened" (May 2001) and striped wolffish as "species of concerns". As such, these species have become the focus of research. The challenge for Fisheries and Oceans is to devise a Recovery Plan and once the Species at Risk Act is passed to determine the level of incidental catch allowed that will not further harm the populations and will permit recovery. Future research will focus on stock structure and life history of these poorly understood species.

PROGNOSIS

In assessing the status of these species, attention must be paid to the declining biomass trends in the 1980's and 1990's, particularly to the north, reduction in extent of the distribution in the north and increasing density to the south. While fishing contributed to the mortality of all species, the species continued to decline when fishing effort was greatly reduced.

An apparent increase in biomass and abundance since the mid-1990's, particularly for striped wolffish is an encouraging sign. However, several more years of survey data are required to confirm that recovery is taking place. Furthermore, with any apparent increase in biomass, it should be expected that the extent of the wolffish distributions should also increase to the range previously observed.

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Table 1a. Biomass of striped wolffish from fall research vessel surveys, 1977-2000. Surveys were conducted with an Engels trawl (1975- fall 1995) and Campelen (1996- 2001).

Fall Year	2J Total Weight (t)	3K Total Weight (t)	3L Total Weight (t)	3N Total Weight (t)	3O Total Weight (t)
1977	11749.50	2231.33			
1978	16363.66	16645.09			
1979	7790.08	10583.27			
1980	6885.71	7552.57			
1981	3864.18	4774.02	3948.50		
1982	4713.62	4355.85	2839.56		
1983	5307.27	5064.10	2439.77		
1984	3868.79	4331.37	4549.86		
1985	3488.42	2993.26	2520.62		
1986	3029.95	0.00	1617.84		
1987	1735.87	1333.36	2923.84		
1988	2192.16	1691.62	3359.31		
1989	1922.60	1343.08	1186.28		
1990	1170.84	697.74	2102.04	3060.03	
1991	534.04	1155.44	818.05	1445.89	1260.22
1992	438.07	347.55	555.80	8576.78	1256.84
1993	444.15	499.35	599.37	2013.98	1323.95
1994	136.56	302.00	411.33	1417.11	498.05
1995	218.32	718.88	1109.66	1390.32	1282.95
1996	908.56	1447.81	784.67	1618.41	968.76
1997	1248.83	567.02	558.90	2159.48	1723.70
1998	1109.86	1370.43	1373.44	3216.68	1960.41
1999	1158.64	1450.41	1678.93	1386.81	1121.64
2000	1584.47	1513.30	2130.54	1699.81	4185.55
2001	1051.05	2236.98	2476.71	2834.84	4740.64

Table 1b. Abundance of striped wolffish from fall research vessel surveys, 1977-2000. Surveys were conducted with an Engels trawl (1975- fall 1995) and Campelen (1996- 2001).

Fall Year	2J Total Number (1,000's)	3K Total Number (1,000's)	3L Total Number (1,000's)	3N Total Number (1,000's)	3O Total Number (1,000's)
1977	13,081.79	2,101.42			
1978	19,341.48	17,332.38			
1979	9,023.48	9,705.50			
1980	8,567.56	8,045.33			
1981	4,131.12	5,128.81	2,337.89		
1982	5,610.17	4,626.81	2,395.37		
1983	6,060.39	4,925.17	1,636.35		
1984	4,856.31	4,170.40	2,945.49		
1985	4,850.04	3,326.45	2,170.61		
1986	3,974.81		1,361.52		
1987	2,299.82	1,937.76	3,590.18		
1988	2,397.40	2,167.17	3,373.05		
1989	2,338.34	1,564.38	1,359.80		
1990	1,560.34	841.64	2,319.25	502.93	
1991	696.21	1,358.26	805.40	549.43	451.20
1992	741.76	528.75	713.53	1,262.00	309.56
1993	848.68	723.21	686.88	411.86	448.39
1994	215.11	418.53	351.28	381.66	232.41
1995	1,499.01	5,134.43	3,734.47	3,579.09	1,346.01
1996	6,105.74	7,927.01	3,312.93	1,359.57	647.26
1997	8,010.54	3,103.89	2,182.81	2,577.54	1,797.48
1998	9,187.72	5,654.40	3,931.26	1,837.76	2,068.99
1999	9,593.57	6,961.86	6,160.42	1,815.87	1,926.41
2000	10,102.61	5,903.37	4,877.88	1,358.84	3,769.88
2001	4,530.21	8,978.06	9,501.28	1,683.20	3,240.88

Table 1c. Biomass of spotted wolffish from fall research vessel surveys, 1977-2000. Surveys were conducted with an Engels trawl (1975- fall 1995) and Campelen (1996- 2001).

Fall Year	2J Total Weight (t)	3K Total Weight (t)	3L Total Weight (t)	3N Total Weight (t)	3O Total Weight (t)
1977	9,414.98				
1978	7,056.15	7,020.17			
1979	7,326.75	6,086.09			
1980	9,097.23	5,723.62			
1981	5,014.51	4,543.36	17,757.72		
1982	7,798.67	4,328.52	17,511.41		
1983	4,931.13	5,382.59	4,824.62		
1984	4,398.59	4,457.06	14,272.74		
1985	1,282.63	1,883.09	4,770.23		
1986	2,654.77		4,686.54		
1987	1,435.74	3,031.80	8,582.76		
1988	1,767.63	2,884.13	5,419.28		
1989	2,001.18	2,654.28	3,701.45		
1990	1,316.55	1,394.48	3,293.82	3.39	
1991	315.53	1,601.02	1,330.37	168.40	6.52
1992	635.89	699.69	1,221.38	153.93	30.68
1993	382.83	307.17	781.59	137.43	6.18
1994	262.79	167.99	599.82	189.69	2.17
1995	60.85	361.26	1,533.28	243.63	7.71
1996	710.66	384.24	52.42	11.77	12.31
1997	553.59	1,319.44	2,250.75	527.74	0.65
1998	595.29	795.47	2,027.89	128.61	26.47
1999	665.67	2,471.16	1,260.75	467.12	175.64
2000	387.43	2,377.03	1,299.76	782.36	
2001	141.34	1,762.37	3,590.05	146.08	10.71

Table 1d. Abundance of spotted wolffish from fall research vessel surveys, 1977-2000. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996- 2001).

Fall Year	2J Total Number (1,000's)	3K Total Number (1,000's)	3L Total Number (1,000's)	3N Total Number (1,000's)	3O Total Number (1,000's)
1977	2,306.06				
1978	2,077.78	1,983.00			
1979	1,571.84	1,654.57			
1980	2,003.95	1,226.23			
1981	949.12	990.28	3,097.90		
1982	1,764.29	1,034.26	2,929.12		
1983	1,104.27	1,319.71	933.67		
1984	1,272.62	1,063.79	2,450.82		
1985	439.69	468.28	905.37		
1986	686.37		801.85		
1987	369.38	538.63	1,425.88		
1988	508.22	683.90	1,149.13		
1989	522.98	670.61	914.97		
1990	284.67	287.31	881.68		
1991	139.36	492.46	363.81	54.46	2.29
1992	191.99	242.27	256.69	47.52	2.29
1993	164.51	93.94	227.74	46.31	2.29
1994	65.12	36.54	87.85	71.42	2.29
1995	80.31	413.20	503.26	236.41	16.88
1996	369.34	463.23	182.26	66.85	11.19
1997	397.75	616.76	513.19	262.87	12.38
1998	138.12	470.17	546.66	100.21	17.81
1999	217.89	1,171.70	721.09	177.32	31.36
2000	256.49	1,723.73	1,032.14	170.10	
2001	188.05	1,951.76	2,281.32	17.25	6.30

Table 1e. Biomass of northern wolffish from fall research vessel surveys, 1977-2000. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996- 2001).

Fall Year	2J Total Weight (t)	3K Total Weight (t)	3L Total Weight (t)	3N Total Weight (t)	3O Total Weight (t)
1977	64,109.42	785.12			
1978	36,350.31	24,514.74			
1979	36,790.85	28,450.90			
1980	47,860.46	21,974.11			
1981	34,269.28	18,534.51	10,964.99		
1982	38,269.50	14,899.39	10,445.69		
1983	35,387.10	17,444.04	7,174.76		
1984	34,020.90	19,924.10	9,316.46		
1985	18,331.97	18,016.54	11,808.53		
1986	21,983.56		7,172.30		
1987	8,813.78	11,005.77	3,591.61		
1988	10,496.42	10,909.50	10,652.82		
1989	7,213.97	7,103.97	5,741.47		
1990	6,576.92	4,751.91	3,860.90		
1991	1,053.18	3,111.50	2,046.09	282.36	8.81
1992	507.16	716.64	1,207.80	228.07	
1993	354.32	557.86	334.24	273.11	793.42
1994	83.33	407.83	559.65	490.11	117.95
1995		466.73	593.09	973.14	493.95
1996	876.02	1,083.01	2,533.76	446.25	122.99
1997	2,367.42	1,234.16	2,234.47	1,001.46	63.12
1998	839.34	2,409.69	2,439.62	1,702.13	576.04
1999	1,066.43	4,463.91	3,083.11	1,152.62	110.49
2000	1,731.18	463.69	1,044.30	820.89	455.04
2001	805.30	2,690.60	1,384.46	834.37	62.81

Table 1f. Abundance of northern wolffish from fall research vessel surveys, 1977-2000. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996- 2001).

Fall Year	2J Total Number (1,000's)	3K Total Number (1,000's)	3L Total Number (1,000's)	3N Total Number (1,000's)	3O Total Number (1,000's)
1977	9,992.22	92.24			
1978	6,033.16	4,203.47			
1979	4,919.44	3,729.83			
1980	7,087.20	2,888.43			
1981	4,662.09	2,380.95	1,199.74		
1982	5,179.96	2,195.28	1,319.88		
1983	4,827.69	2,269.98	1,033.12		
1984	4,402.90	2,405.68	1,261.59		
1985	2,528.34	2,110.41	1,203.17		
1986	2,418.87		900.95		
1987	1,179.27	1,166.54	384.02		
1988	1,113.90	1,014.88	1,003.49		
1989	721.26	532.08	479.82		
1990	627.42	454.22	340.22		
1991	114.81	276.30	238.03	44.07	2.29
1992	64.02	78.21	157.51	35.58	
1993	36.26	48.93	59.36	57.27	54.74
1994	26.92	80.67	98.51	104.11	22.41
1995		123.92	100.93	209.15	131.31
1996	175.60	276.41	552.53	88.78	24.15
1997	331.53	301.88	354.40	279.78	39.10
1998	181.89	422.09	391.94	316.90	124.08
1999	143.09	644.19	476.29	191.32	26.55
2000	293.62	382.26	275.42	176.56	30.39
2001	119.79	463.19	261.34	258.32	30.78

Table 1g. Biomass estimates of striped wolffish from spring research vessel surveys, 1971-2001. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996-2001).

Spring Year	3L Total Weight (t)	3N Total Weight (t)	3O Total Weight (t)	3P Total Weight (t)
1971	4371.02	69.44		
1972	408.70	1641.16		2831.64
1973	575.08	4008.21	2336.14	10962.47
1974	1252.45	3225.04		1431.57
1975	3644.39	7640.59	388.31	1727.83
1976	2781.31	5853.83	2081.15	3560.22
1977	5197.17	3227.26	808.23	2559.50
1978	1488.08	2739.63	2194.58	429.38
1979	5289.03	7199.61	2403.28	1348.60
1980	5302.15	8977.15	2375.11	2117.77
1981	5655.89	2283.27	414.54	4665.66
1982	4820.53	13579.23	2217.53	1646.62
1983				2264.97
1984		7691.47	3007.35	2158.34
1985	1561.73	9999.50	4201.48	1524.75
1986	2556.80	15158.14	1750.46	1927.41
1987	3302.28	9443.14	4539.51	539.53
1988	2377.95	7850.69	4233.71	311.73
1989	1941.52	7507.94	3159.76	223.72
1990	1791.96	11101.82	2352.51	515.12
1991	396.13	6199.84	2258.36	305.56
1992	416.88	6338.89	1748.73	42.74
1993	517.18	5124.97	2507.32	252.79
1994	553.11	12111.46	2599.62	208.21
1995	128.89	3213.05	598.00	349.37
1996	1134.91	3187.27	1350.35	1230.12
1997	1066.85	5251.69	772.24	183.58
1998	1109.99	3385.73	2882.74	633.02
1999	1952.86	4418.65	3629.28	4574.49
2000	2213.27	4265.25	3206.42	1534.49
2001	1329.18	17016.78	2440.74	1612.44

Table 1h. Abundance estimates of striped wolffish from spring research vessel surveys, 1971-2001. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996-2001).

Spring Year	3L Total Number (1,000's)	3N Total Number (1,000's)	3O Total Number (1,000's)	3P Total Number (1,000's)
1971	4,023.89	35.19		
1972	321.11	495.05		882.12
1973	376.10	555.57	558.25	2,355.13
1974	1,298.90	356.77		1,104.53
1975	4,499.93	753.06	248.17	970.16
1976	2,913.21	502.27	1,226.15	1,291.01
1977	3,945.02	353.02	118.75	1,377.82
1978	1,113.41	679.17	453.85	631.13
1979	4,154.53	675.69	412.54	747.46
1980	3,601.87	926.48	449.18	501.09
1981	4,272.00	395.19	130.27	1,554.90
1982	3,149.63	1,520.61	545.61	962.66
1983				516.45
1984		795.53	367.12	416.79
1985	1,054.52	1,144.05	545.87	393.36
1986	1,566.98	1,377.50	311.47	618.77
1987	3,106.77	886.98	812.16	370.32
1988	2,022.70	786.08	1,230.81	258.48
1989	2,294.06	671.92	918.61	110.80
1990	2,139.14	1,347.43	661.91	154.29
1991	281.02	822.10	1,001.16	182.21
1992	577.83	700.35	359.72	100.80
1993	627.86	871.34	445.82	125.52
1994	840.15	1,483.17	471.50	126.63
1995	199.83	387.72	199.94	184.20
1996	3,322.92	2,030.01	1,269.33	4,443.12
1997	3,318.84	2,053.12	2,444.29	1,053.61
1998	1,877.76	1,490.66	1,728.33	891.52
1999	3,988.29	1,366.91	3,154.17	5,945.41
2000	8,281.84	1,656.79	1,833.83	2,169.80
2001	3,236.85	3,415.15	2,095.52	3,708.84

Table 1i. Biomass estimates of spotted wolffish from spring research vessel surveys, 1971-2001. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996-2001).

Spring Year	3L Total Number (1,000's)	3N Total Number (1,000's)	3O Total Number (1,000's)	3P Total Number (1,000's)
1971	1,676.45			
1972	243.45	4.22		10.87
1973	30.73	36.78	2.29	2.07
1974	500.61	18.37		7.86
1975	1,396.80			52.43
1976	1,094.44		89.73	12.61
1977	1,612.00	46.50	0.00	21.82
1978	523.51	72.23	14.16	19.77
1979	1,438.74	58.95		
1980	1,364.38	68.57		
1981	2,564.01	195.79		
1982	1,206.54	27.02	27.67	
1983				19.47
1984	26.45	35.96	11.41	11.45
1985	382.07			28.92
1986	410.57	17.87		
1987	709.20	3.98		
1988	801.95	7.96	4.54	15.50
1989	650.12		23.98	
1990	570.08	17.34	7.39	11.11
1991	103.05	34.53	14.23	
1992	136.28	41.02	2.85	
1993	117.33	47.25		
1994	90.86	7.96	5.70	
1995	67.75	56.64	4.47	4.73
1996	535.54	73.87		
1997	327.29	85.43	9.49	13.27
1998	538.52	142.60		
1999	604.84	90.20	46.92	18.11
2000	1,052.54	57.10	4.18	52.18
2001	878.66	122.60		36.22

Table 1j. Abundance estimates of spotted wolffish from spring research vessel surveys, 1971-2001. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996-2001).

Spring Year	3L Total Number (1,000's)	3N Total Number (1,000's)	3O Total Number (1,000's)	3P Total Number (1,000's)
1971	1,676.45			
1972	243.45	4.22		10.87
1973	30.73	36.78	2.29	2.07
1974	500.61	18.37		7.86
1975	1,396.80			52.43
1976	1,094.44		89.73	12.61
1977	1,612.00	46.50	0.00	21.82
1978	523.51	72.23	14.16	19.77
1979	1,438.74	58.95		
1980	1,364.38	68.57		
1981	2,564.01	195.79		
1982	1,206.54	27.02	27.67	
1983				19.47
1984	26.45	35.96	11.41	11.45
1985	382.07			28.92
1986	410.57	17.87		
1987	709.20	3.98		
1988	801.95	7.96	4.54	15.50
1989	650.12		23.98	
1990	570.08	17.34	7.39	11.11
1991	103.05	34.53	14.23	
1992	136.28	41.02	2.85	
1993	117.33	47.25		
1994	90.86	7.96	5.70	
1995	67.75	56.64	4.47	4.73
1996	535.54	73.87		
1997	327.29	85.43	9.49	13.27
1998	538.52	142.60		
1999	604.84	90.20	46.92	18.11
2000	1,052.54	57.10	4.18	52.18
2001	878.66	122.60		36.22

Table 1k. Biomass estimates of Northern wolffish from spring research vessel surveys, 1971-2001. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996-2001).

Spring Year	3L Total Weight (t)	3N Total Weight (t)	3P Total Weight (t)	3O Total Weight (t)
1971	6,403.34		0.00	
1972		55.52	168.41	
1973			258.25	
1974	116.72	23.68	51.44	
1975	1,123.13		348.45	
1976	874.67		2,962.37	
1977	3,080.20	147.85	320.06	32.97
1978	1,141.54	522.54	766.60	
1979	4,753.36	446.87	296.66	361.28
1980	5,425.81	56.70	181.53	94.02
1981	6,007.46	2,320.33	97.55	
1982	1,444.61		1,025.12	
1983			769.26	
1984			973.29	
1985	2,966.60		1,045.06	315.97
1986	174.66		240.45	213.48
1987	3,861.59	3.58	362.37	18.32
1988	9,700.37		69.47	
1989	4,403.58		471.10	8.47
1990	1,217.15		122.79	
1991	20.22	28.62	133.86	
1992	281.13	75.44	44.28	482.47
1993	32.54	562.54	136.37	125.45
1994	735.60	5.07	49.87	94.41
1995	352.44	23.27	240.45	31.66
1996	209.72	153.50	302.80	1,072.95
1997	733.83	2,066.25		
1998	1,491.33	325.14	262.26	284.88
1999	1,049.66	467.45	213.85	157.11
2000	1,542.83	406.09		927.77
2001	696.42	200.57	45.09	102.44

Table 1L. Abundance estimates of Northern wolffish from spring research vessel surveys, 1971-2001. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996-2001).

Spring Year	3L Total Number (1,000's)	3N Total Number (1,000's)	3O Total Number (1,000's)	3P Total Number (1,000's)
1971	764.95			0.00
1972		7.77		27.44
1973				17.79
1974	36.04	4.35		9.69
1975	188.43			58.84
1976	105.57			323.70
1977	441.91	49.53	4.54	36.81
1978	162.16	68.72		80.09
1979	728.34	78.97	38.73	62.68
1980	680.96	8.21	30.89	11.11
1981	753.75	289.04		22.43
1982	221.43			127.01
1983				129.29
1984				69.11
1985	443.87		31.76	92.66
1986	25.10		14.23	21.93
1987	471.16	3.98	2.29	58.01
1988	883.69			30.68
1989	414.87		2.29	73.19
1990	96.11			54.61
1991	9.63	4.65		18.85
1992	92.07	17.38	50.97	29.04
1993	12.76	46.78	36.34	31.96
1994	126.93	3.90	23.72	24.93
1995	87.79	4.65	12.47	87.88
1996	85.98	50.59	93.04	132.96
1997	131.70	193.61		
1998	411.73	123.14	99.58	64.85
1999	210.49	168.77	38.39	103.28
2000	434.03	110.05	97.59	
2001	185.57	112.56	19.30	17.34

Table 1M. Abundance estimates of striped wolffish from occasional fall research vessel surveys occurring between , 1978-2001 in NAFO divisions 2GH.

	Division 2H		Division 2G	
Year	Total Number (1,000's)	Total Weight (t)	Total Number (1,000's)	Total Weight (t)
1978	5,620.83	3,690.32	1,614.83	1,268.38
1979	4,766.52	3,328.23	1,477.38	930.66
1981	2,420.70	2,599.62	612.78	653.51
1987	396.38	259.52	329.89	179.05
1988	919.69	583.14	42.69	56.57
1991	134.74	111.94		
1996	1,691.10	231.36	1,421.81	276.51
1997	2,263.41	337.92	3,384.45	482.43
1998	5,647.59	510.52	1,126.37	47.96
1999	4,100.67	468.99	2,950.38	287.37
2001	726.49	56.47		

Table 1N. Abundance estimates of Northern wolffish from occasional fall research vessel surveys occurring between , 1978-2001 in NAFO divisions 2GH.

	Division 2H		Division 2G	
Year	Total Number (1,000's)	Total Weight (t)	Total Number (1,000's)	Total Weight (t)
1978	3,328.92	24,553.13	3,810.76	34,690.85
1979	4,670.63	31,681.24	3,179.06	23,958.38
1981	4,690.80	40,265.99	4,482.11	46,368.93
1987	346.09	2,655.78	232.13	2,279.33
1988	182.17	1,754.23	162.03	890.56
1991	0.00	0.00	0.00	0.00
1996	47.57	150.66	0.00	0.00
1997	6.67	7.34	73.63	192.86
1998	11.11	58.91	55.99	901.68
1999	177.59	440.21	36.55	134.89
2001	0.00	0.00		

Table 1O. Abundance estimates of spotted wolffish from occasional fall research vessel surveys occurring between , 1978-2001 in NAFO divisions 2GH.

	Division 2H		Division 2G	
Year	Total Number (1,000's)	Total Weight (t)	Total Number (1,000's)	Total Weight (t)
1978	1,068.77	5,842.96	740.24	2,672.07
1979	1,122.61	3,503.64	337.10	1,545.52
1981	1,144.21	7,180.72	496.61	3,905.25
1987	297.03	1,271.90	40.33	10.34
1988	366.66	1,279.16	37.43	91.37
1991	57.20	43.55	31.98	57.06
1996	165.77	418.07	370.87	810.14
1997	155.44	411.10	232.18	411.35
1998	265.78	355.03	32.81	95.62
1999	213.43	927.86	157.60	513.68
2001	35.79	113.96		

Table 2a: Relative size (=total biomass/total number) of striped wolffish from DFO fall research survey cruises. Surveys were conducted with an Engels trawl (1971- fall 1995) and Campelen (spring 1996-2001).

Fall Year	2J Relative Size	3K Relative Size	3L Relative Size	3N Relative Size	3O Relative Size
1977	0.90	1.06			
1978	0.85	0.96			
1979	0.86	1.09			
1980	0.80	0.94			
1981	0.94	0.93	1.69		
1982	0.84	0.94	1.19		
1983	0.88	1.03	1.49		
1984	0.80	1.04	1.54		
1985	0.72	0.90	1.16		
1986	0.76		1.19		
1987	0.75	0.69	0.81		
1988	0.91	0.78	1.00		
1989	0.82	0.86	0.87		
1990	0.75	0.83	0.91	6.08	
1991	0.77	0.85	1.02	2.63	2.79
1992	0.59	0.66	0.78	6.80	4.06
1993	0.52	0.69	0.87	4.89	2.95
1994	0.63	0.72	1.17	3.71	2.14
1995	0.15	0.14	0.30	0.39	0.95
1996	0.15	0.18	0.24	1.19	1.50
1997	0.16	0.18	0.26	0.84	0.96
1998	0.12	0.24	0.35	1.75	0.95
1999	0.12	0.21	0.27	0.76	0.58
2000	0.16	0.26	0.44	1.25	1.11
2001	0.23	0.25	0.26	1.68	1.46

Table 2b: Relative size (=total biomass/total number) of spotted wolffish from DFO fall research survey cruises. Surveys were conducted with an Engels trawl (1977- fall 1995) and Campelen (spring 1996-2001).

Fall Year	2J Relative Size	3K Relative Size	3L Relative Size	3N Relative Size	3O Relative Size
1977	4.08				
1978	3.40	3.54			
1979	4.66	3.68			
1980	4.54	4.67			
1981	5.28	4.59	5.73		
1982	4.42	4.19	5.98		
1983	4.47	4.08	5.17		
1984	3.46	4.19	5.82		
1985	2.92	4.02	5.27		
1986	3.87		5.84		
1987	3.89	5.63	6.02		
1988	3.48	4.22	4.72		
1989	3.83	3.96	4.05		
1990	4.62	4.85	3.74		
1991	2.26	3.25	3.66	3.09	2.85
1992	3.31	2.89	4.76	3.24	13.40
1993	2.33	3.27	3.43	2.97	2.70
1994	4.04	4.60	6.83	2.66	0.95
1995	0.76	0.87	3.05	1.03	0.46
1996	1.92	0.83	0.29	0.18	1.10
1997	1.39	2.14	4.39	2.01	0.05
1998	4.31	1.69	3.71	1.28	1.49
1999	3.06	2.11	1.75	2.63	5.60
2000	1.51	1.38	1.26	4.60	
2001	0.75	0.90	1.57	8.47	1.70

Table 2c: Relative size (=total biomass/total number) of Northern wolffish from DFO fall research survey cruises. Surveys were conducted with an Engels trawl (1977- fall 1995) and Campelen (spring 1996-2001).

Fall Year	2J Relative Size	3K Relative Size	3L Relative Size	3N Relative Size	3O Relative Size
1977	6.42	8.51			
1978	6.03	5.83			
1979	7.48	7.63			
1980	6.75	7.61			
1981	7.35	7.78	9.14		
1982	7.39	6.79	7.91		
1983	7.33	7.68	6.94		
1984	7.73	8.28	7.38		
1985	7.25	8.54	9.81		
1986	9.09		7.96		
1987	7.47	9.43	9.35		
1988	9.42	10.75	10.62		
1989	10.00	13.35	11.97		
1990	10.48	10.46	11.35		
1991	9.17	11.26	8.60	6.41	3.85
1992	7.92	9.16	7.67	6.41	
1993	9.77	11.40	5.63	4.77	14.49
1994	3.10	5.06	5.68	4.71	5.26
1995		3.77	5.88	4.65	3.76
1996	4.99	3.92	4.59	5.03	5.09
1997	7.14	4.09	6.30	3.58	1.61
1998	4.61	5.71	6.22	5.37	4.64
1999	7.45	6.93	6.47	6.02	4.16
2000	5.90	1.21	3.79	4.65	14.97
2001	6.72	5.81	5.30	3.23	2.04

Table 3. Number of sets and average number of young of the year striped per set taken in IGYPT trawls, 1996-1999. Average trawl depth was 30 m below the surface.

year	Number of fish	Count of sets
1996	0	124
	1	16
	2	6
	3	4
	4	1
	5	1
	6	2
	7	1
	10	1
	12	1
	15	1
Total		158
1997	0	103
	1	22
	2	7
	3	7
	4	4
	5	3
	6	2
	8	1
	9	1
	11	1
	22	1
Total		152
1998	0	102
	1	18
	2	4
	3	3
	4	1
	6	1
	10	2
	12	1
Total		132
1999	0	102
	1	12
	2	6
	3	2
	4	2
	5	1
	6	1
	7	1
	11	1
	14	1
	19	1
	21	1
Total		131
All years Total		597

Table 4. Landing of wolffish (species combined): upper table by country by NAFO Division, lower table by NAFO Divison (Canada only).

	2J		3K		3L		3N		3O		3Ps		3Pn		
Year	Can	non Can	Can	non Can	Can	non Can	Can	non Can	Can	non Can	Can	non Can	Can	non Can	Total
1985	2	14	114	52	1,015	39	87	33	69		113	55	23		1,617
1986	28	10	287	41	434		191	236	55	11	102	71	41		1,507
1987	46	429	60	43	754	5	335	108	156	21	123	60	52		2,192
1988	11	2	103	18	587	1	222	159	69	7	90	54	24		1,346
1989	83		140	8	598		140	63	72	3	95	51	34		1,287
1990	56		60	2	347	668	44	187	41		94		22		1,521
1991	1		52		331	1,277	56	654	45	22	97		43		2,579
1992	2		20		30	60	50	104	78	111	112	13	50		629
1993	0		4		5	4	42	144	131	19	64		68		481
1994	0		13		1	67	2	124	1	32	14		2		256
1995	0		5		1	112		76	1	21	13		9		237
1996	1		8		1	489	1	140	1	10	8		3		662
1997	2	3	9		3	293	0	236	5	43	45		92		732
1998	1		0		0	242	2	180	2	30	91	3	58		610
1999	2		2		0		9		8		229		65		315
2000			8		4		20		0		268		68		369
2001	2		10		3				1		93		51		160

Wolffish	2H	2J	3K	3L	3N	3O	3Pn	3Ps	All
1985	0.1	2.4	114.3	1014.8	87.3	69.5	22.8	112.9	1424.1
1986	0.1	28.3	286.7	434.0	191.3	55.2	40.7	101.8	1138.0
1987	0.0	46.2	60.3	753.6	334.8	156.5	52.5	122.5	1526.4
1988	0.0	11.1	103.1	586.9	221.6	68.5	24.2	89.5	1104.8
1989	0.2	83.3	140.1	598.1	139.5	72.3	34.0	95.1	1162.6
1990	0.1	56.4	59.9	346.5	44.3	41.0	21.7	94.1	663.9
1991	20.1	1.4	52.4	330.6	56.4	45.3	42.6	97.0	645.9
1992	2.6	1.5	19.9	30.1	49.7	77.7	50.3	111.8	343.6
1993	0.0	0.5	3.6	5.1	42.4	130.8	68.3	63.7	314.3
1994	0.2	0.3	12.6	1.3	1.8	1.3	2.4	13.6	33.5
1995	0.0	0.1	4.8	0.6	0.0	0.9	8.6	12.5	27.6
1996	0.0	1.0	7.6	0.7	0.9	1.2	3.3	8.3	22.9
1997	0.0	2.5	8.7	3.3	0.1	4.6	92.2	45.1	156.5
1998	0.0	0.8	0.3	0.1	1.9	2.4	58.5	91.4	155.3
1999	0.0	2.2	1.9	0.5	8.8	7.8	65.2	228.8	315.2
2000	0.0	0.0	8.5	4.1	20.1	0.3	68.2	267.7	369.0
2001	0.0	2.0	10.0	3.0		1.0	51.0	93.0	160.0

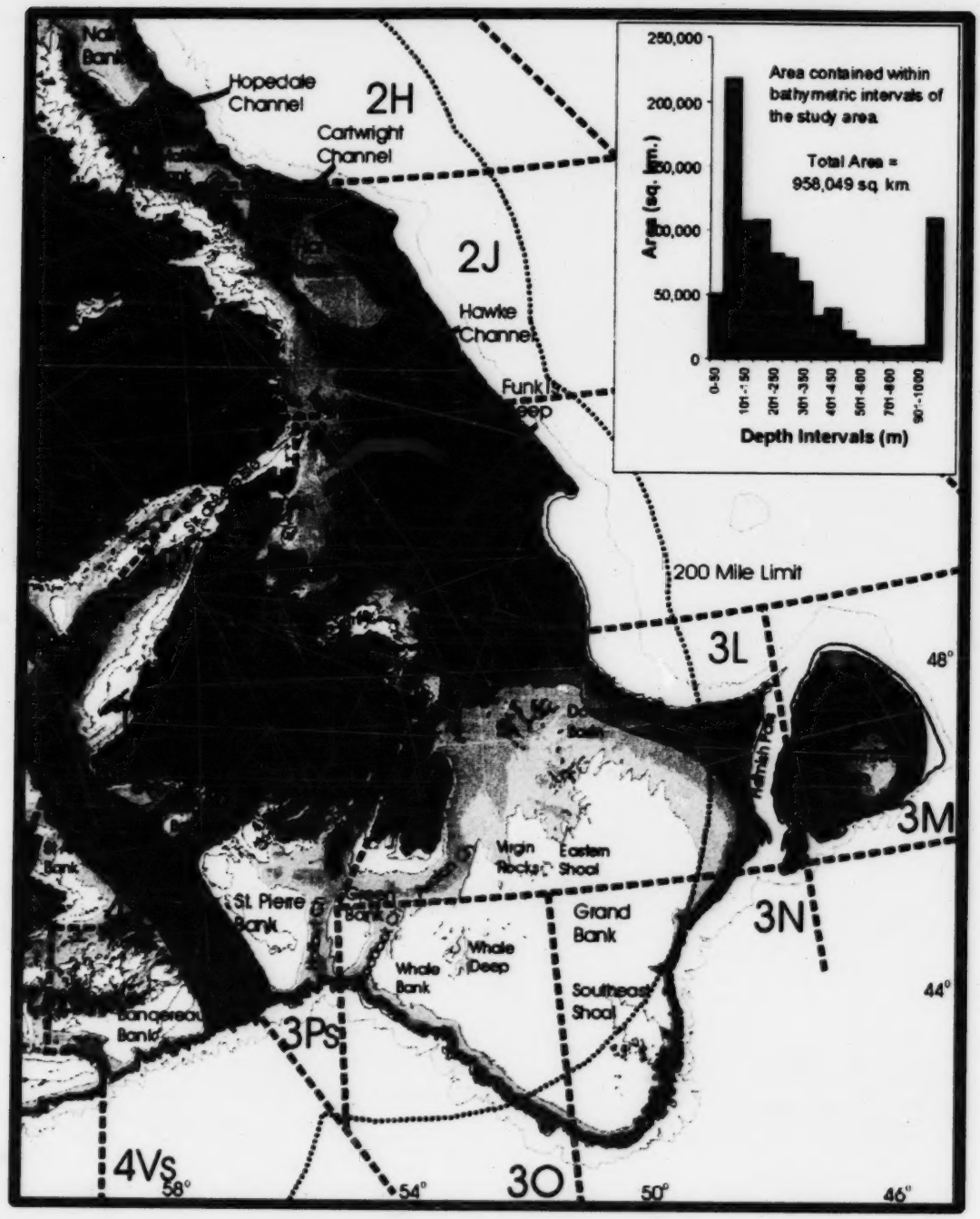

Figure 1. Map of the Grand Banks, northeast Newfoundland Shelf and Labrador Shelf showing various banks, basins and NAFO Divisions.

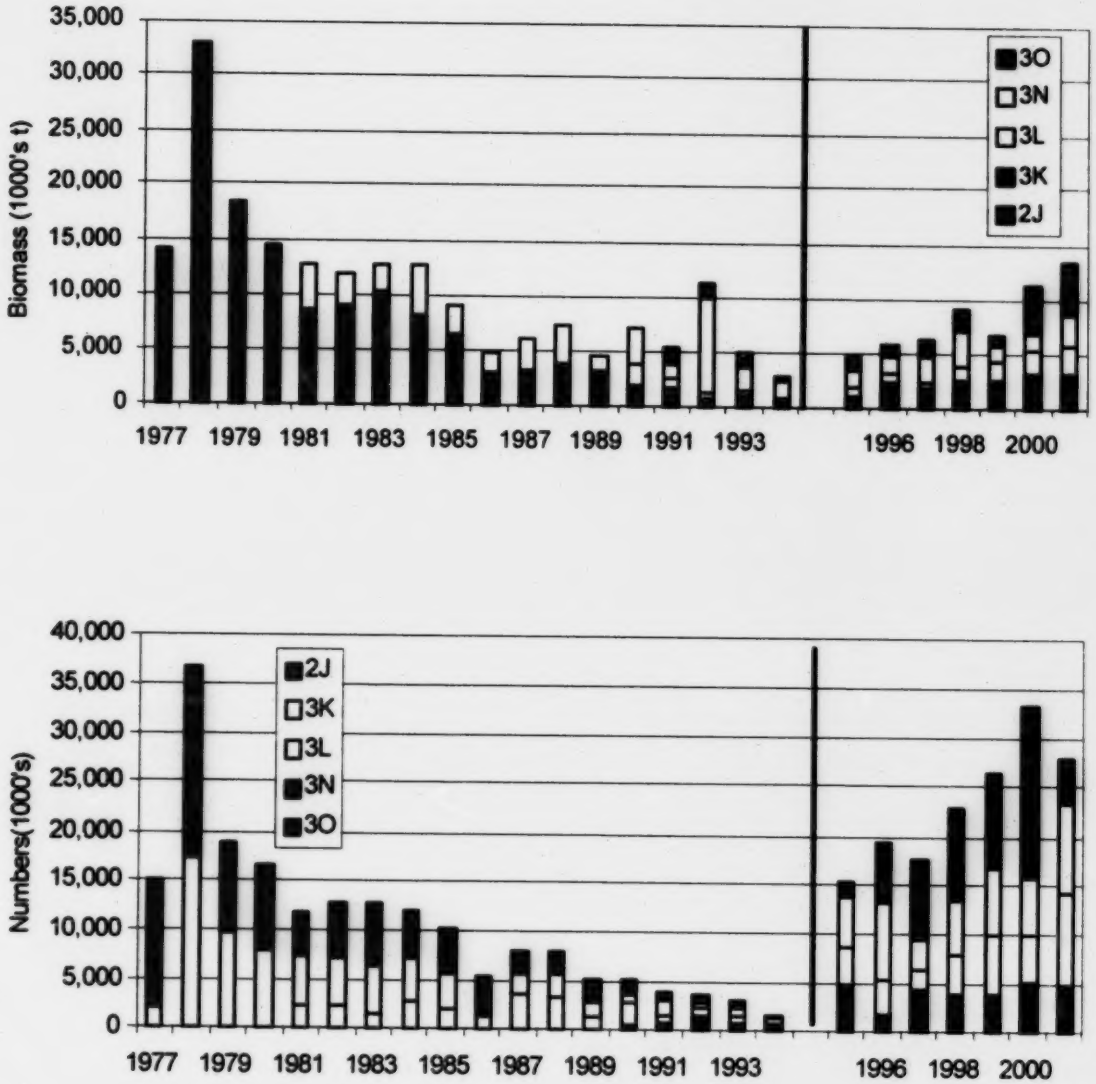

Figure 2a. Fall research survey biomass (upper panel) and abundance (lower panel) indices for striped wolffish in NAFO Divisions 2J and3KLNO, 1977-2001.

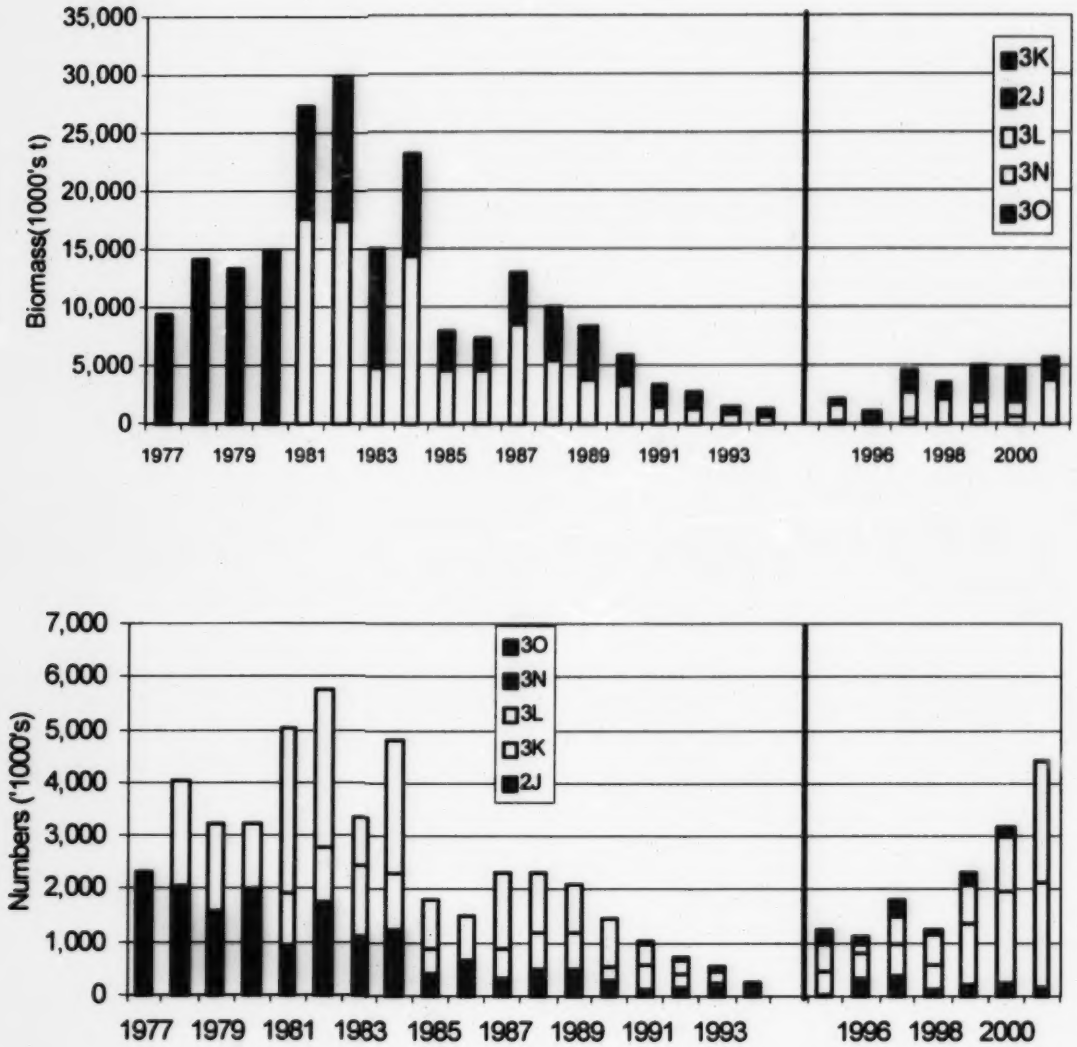

Figure 2b. Fall research survey biomass (upper) and abundance (lower) indices for spotted wolffish in NAFO Divisions 2J and3KLNO, 1977-2001.

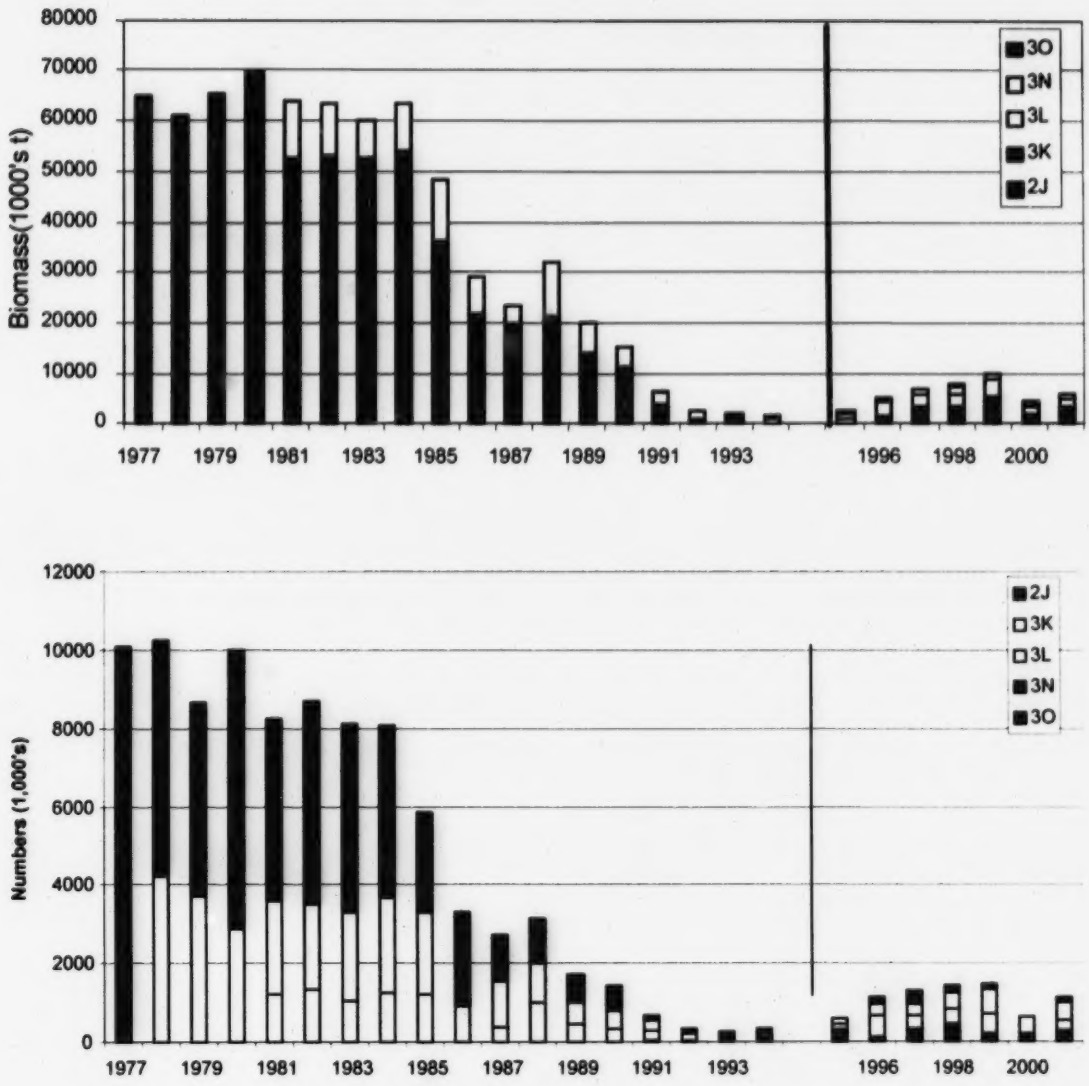

Figure 2c. Fall research survey biomass (upper) and abundance (lower) indices for northern wolffish in NAFO Divisions 2J and3KLNO, 1977-2001.

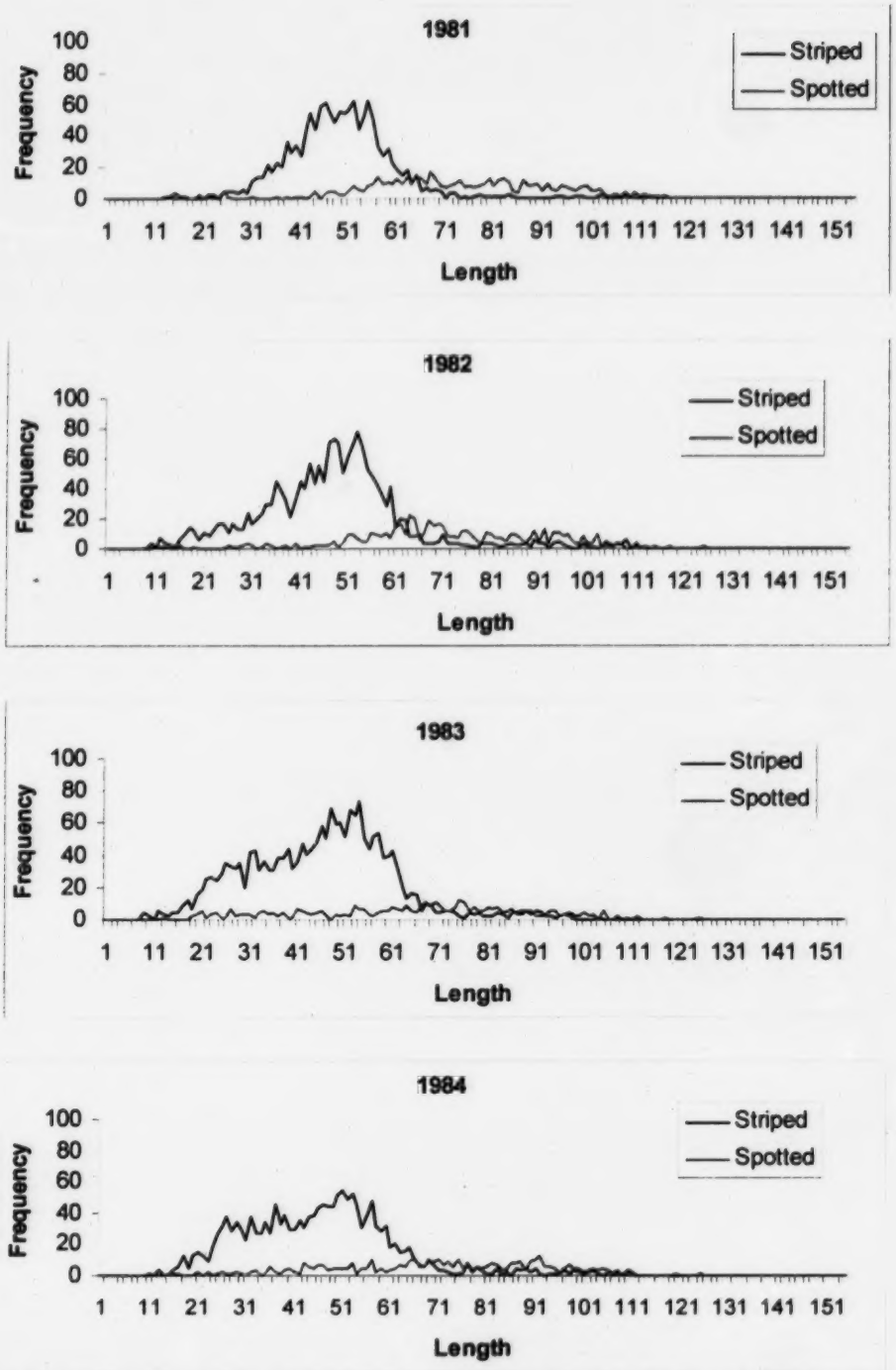

Figure 3a. Length frequencies of striped and spotted wolffish caught in NAFO Divisions 2J3KLNO during fall groundfish research in surveys, 1981-1984.

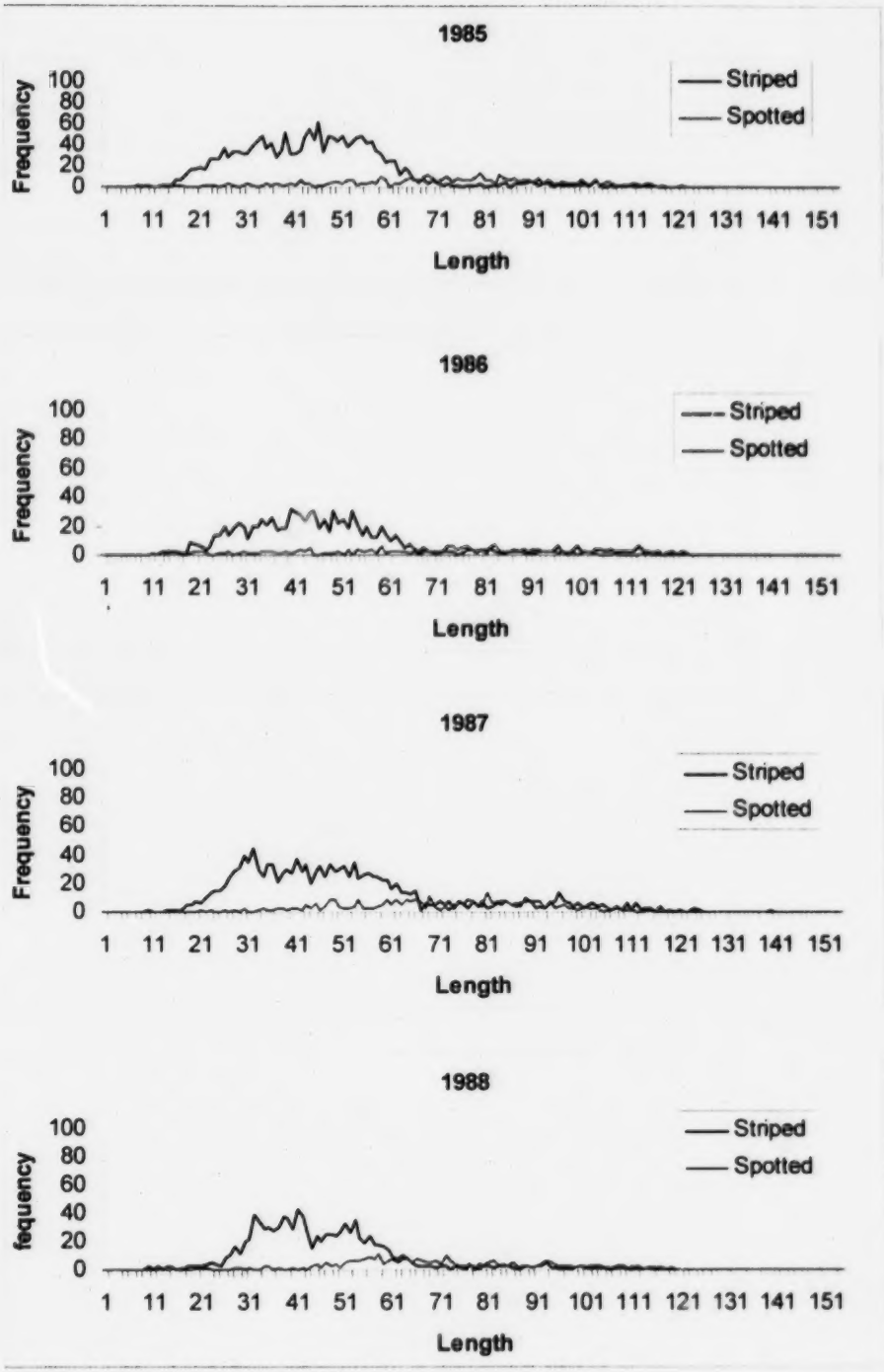

Figure 3b. Length frequencies of striped and spotted wolffish caught in NAFO Divisions 2J3KLNO during fall groundfish research in surveys, 1985-1988.

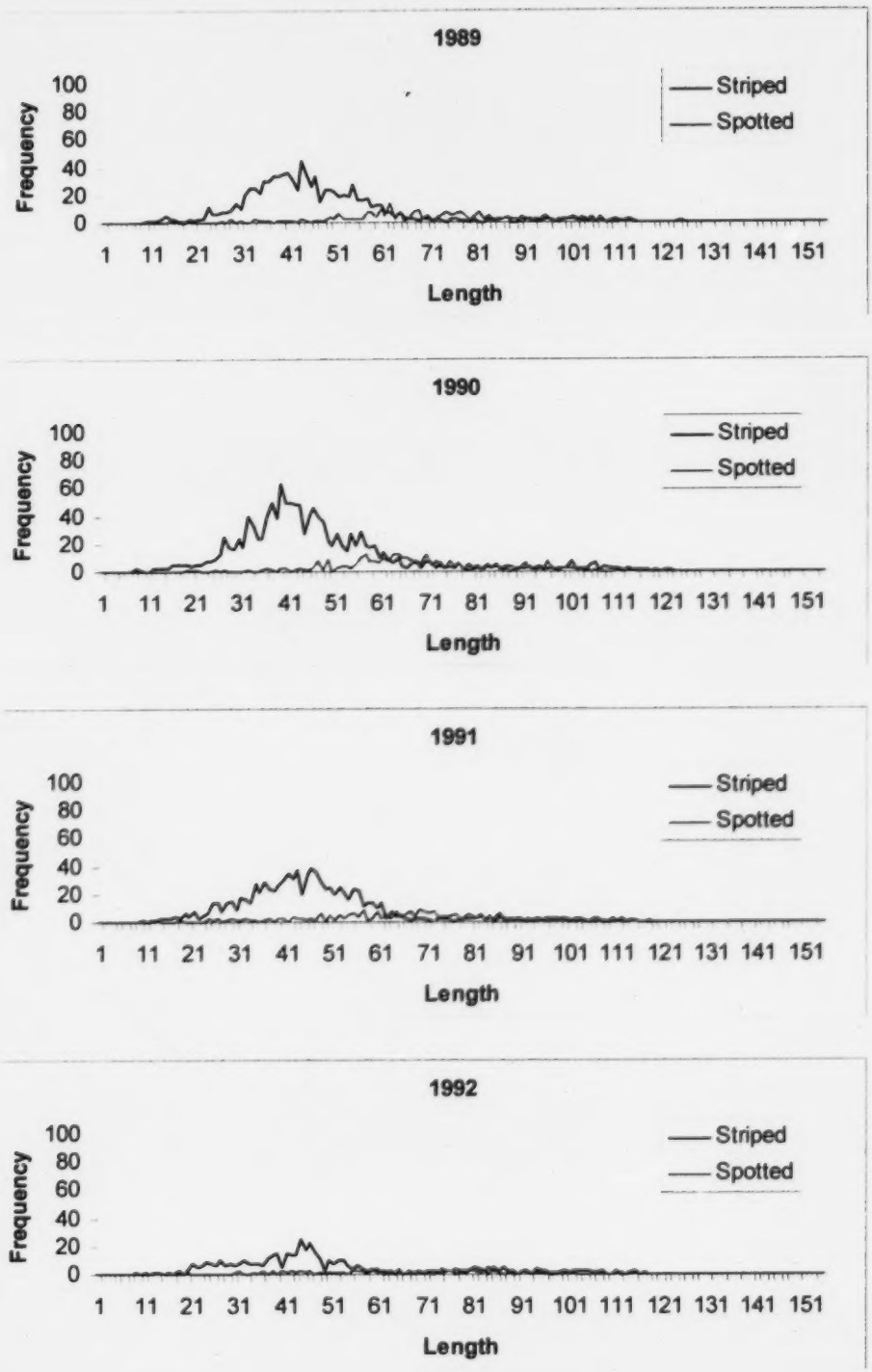

Figure 3c. Length frequencies of striped and spotted wolffish caught in NAFO Divisions 2J3KLNO during fall groundfish research in surveys, 1989-1992.

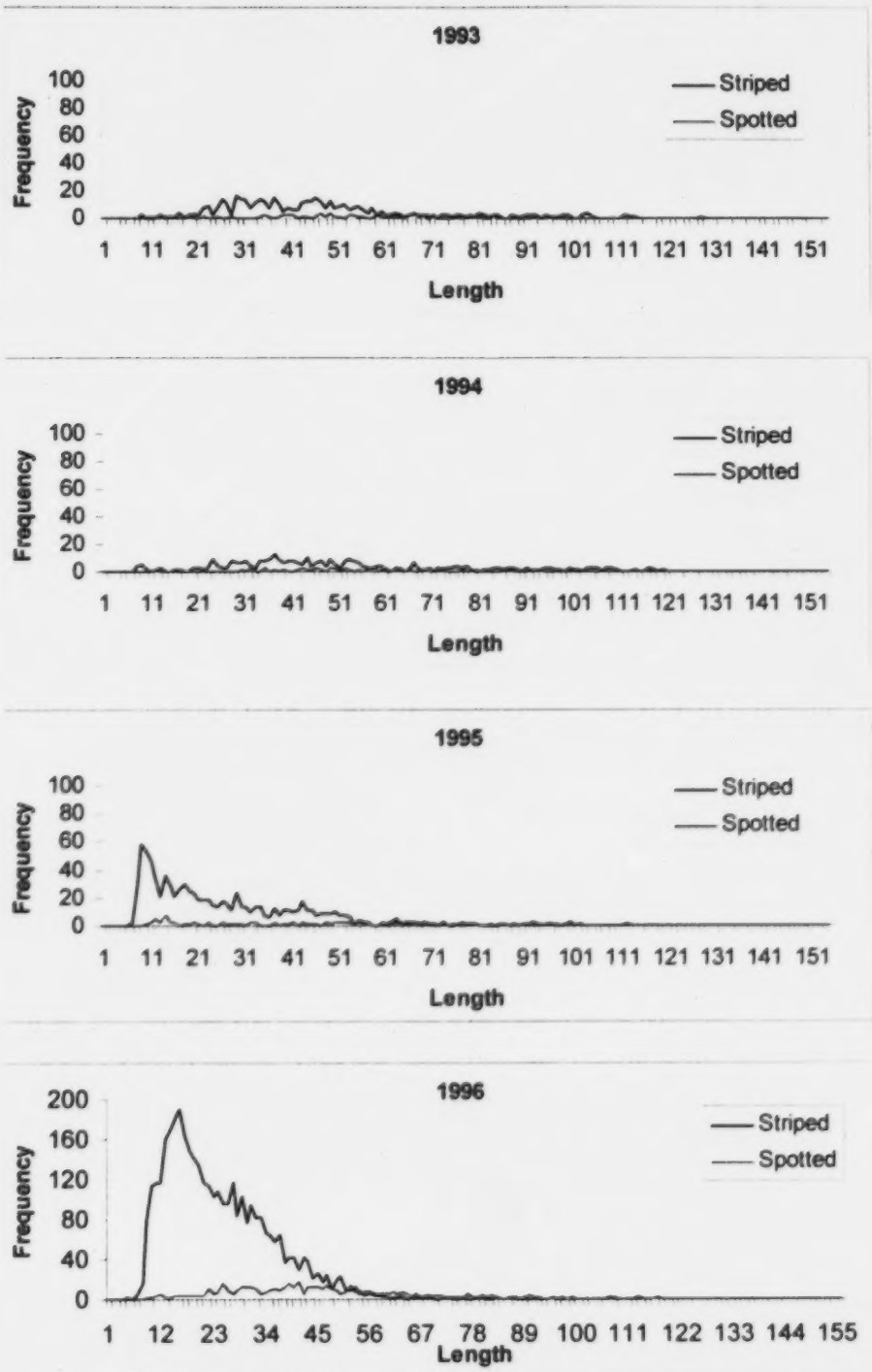

Figure 3d. Length frequencies of striped and spotted wolffish caught in NAFO Divisions 2J3KLNO during fall groundfish research in surveys, 1993-1996.

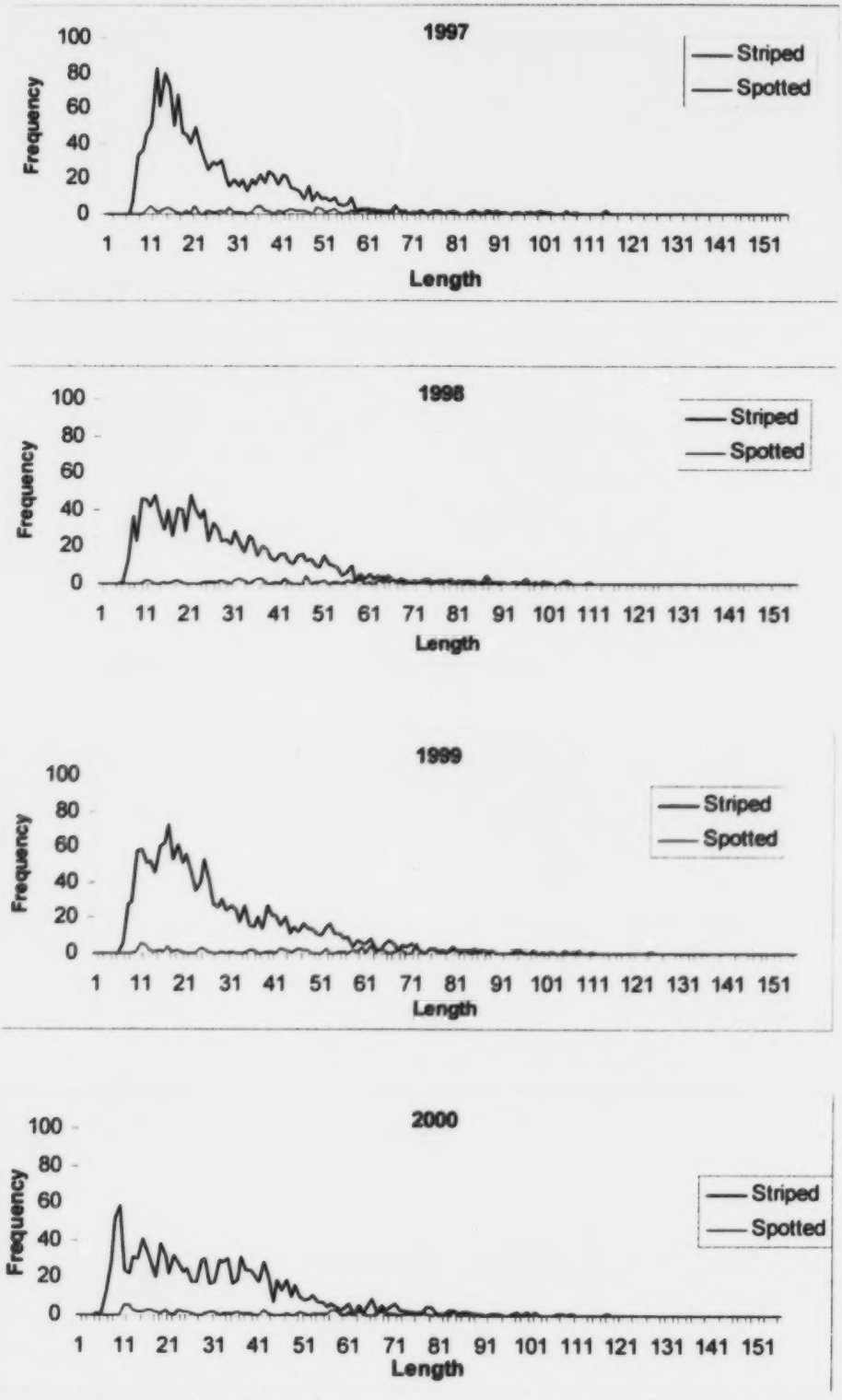

Figure 3e. Length frequencies of striped and spotted wolffish caught in NAFO Divisions 2J3KLNO during fall groundfish research in surveys, 1997-2000.

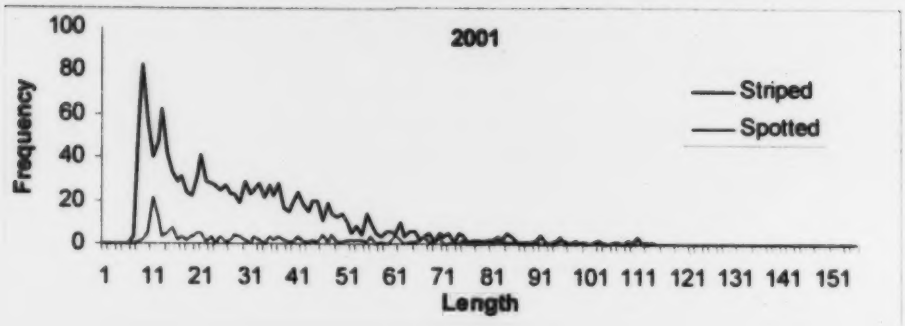

Figure 3f: Length frequencies of striped and spotted wolffish caught in NAFO Divisions 2J3KLNO during fall groundfish research in surveys, 1997-2000.

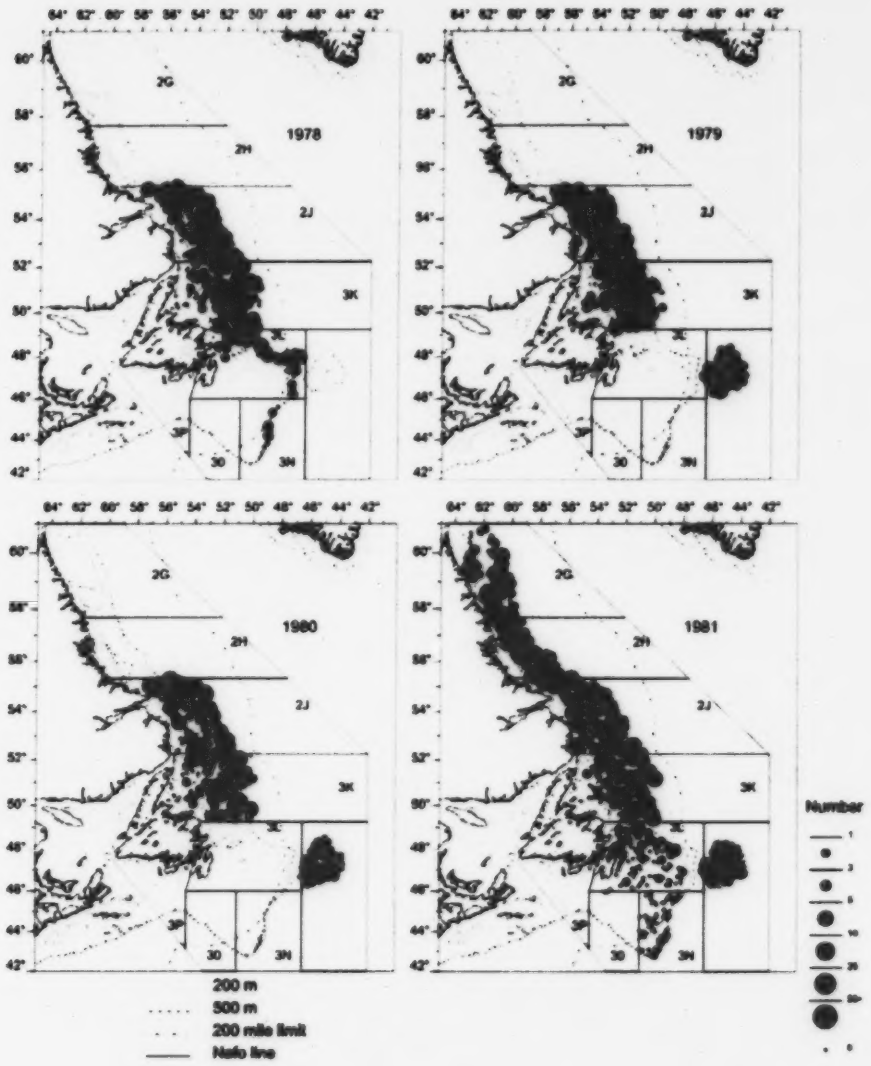

Figure 4a: Distribution of Northern wolffish catches, 1978-1981, from fall DFO RV survey cruises.

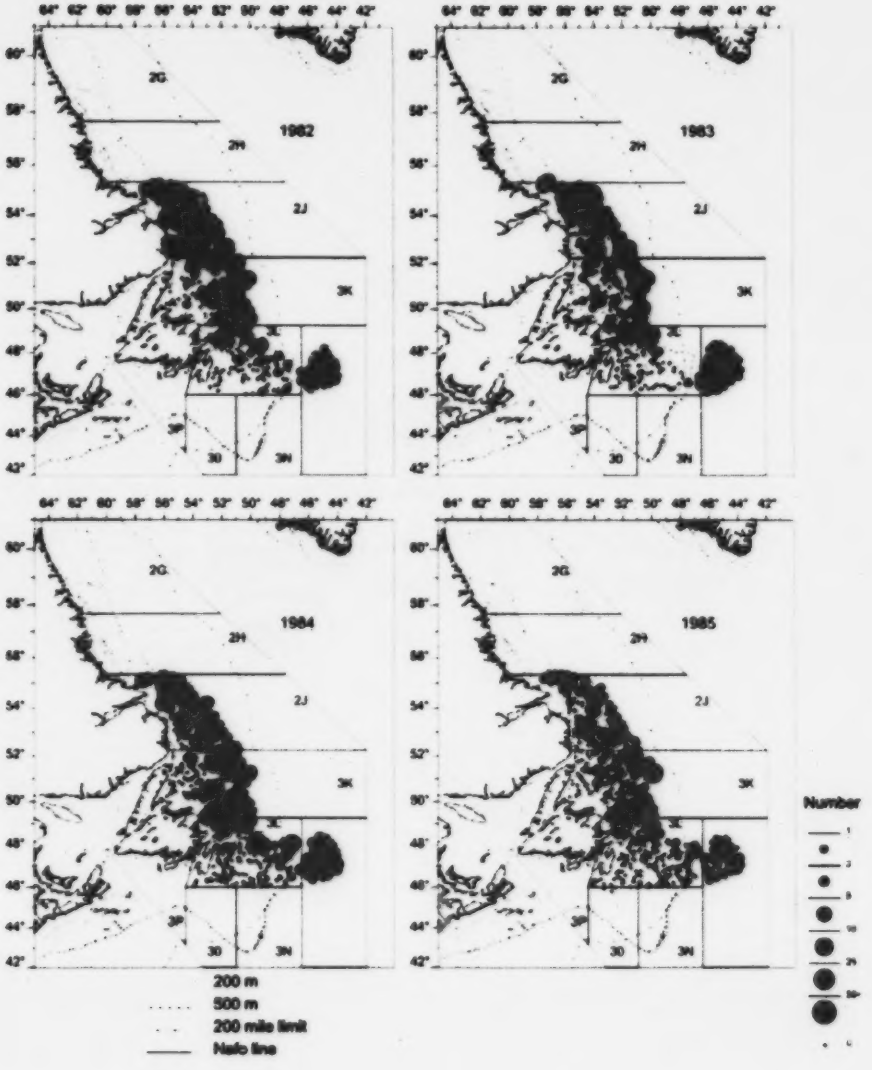

Figure 4b: Distribution of Northern wolffish catches, 1982-1985, from fall DFO RV survey cruises.

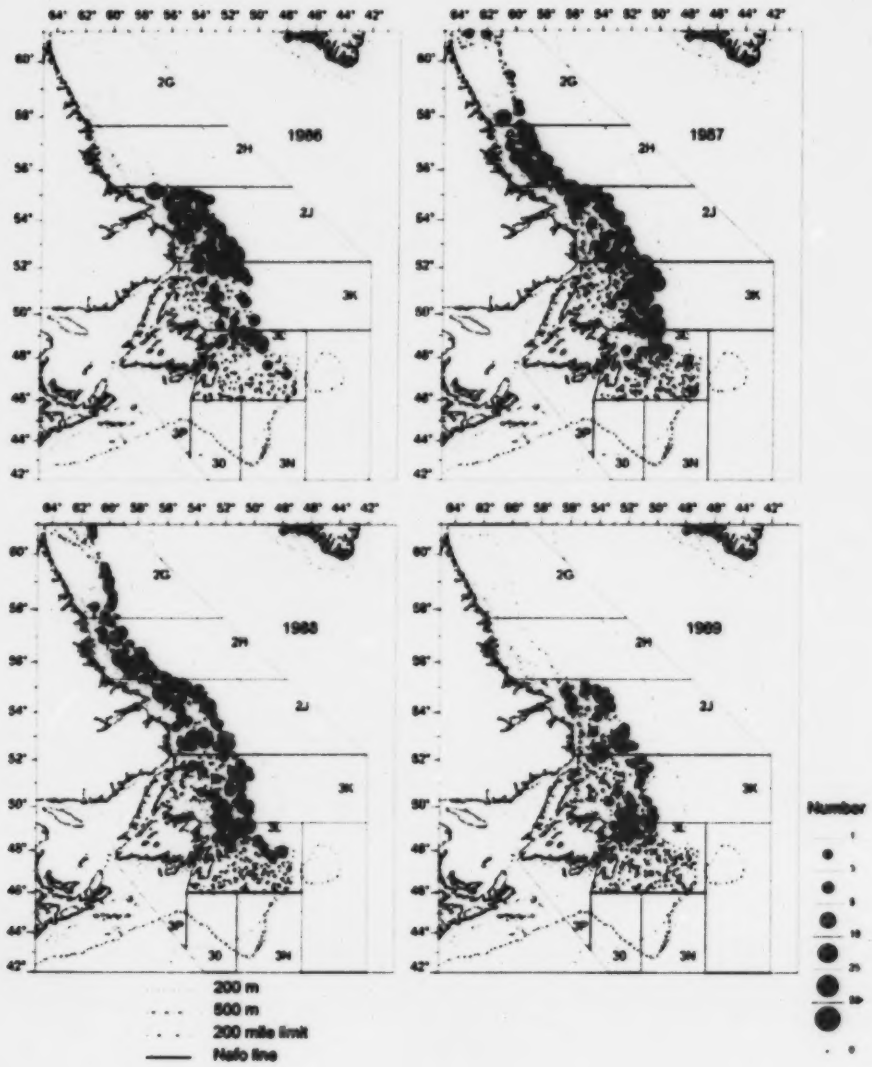

Figure 4c: Distribution of Northern wolffish catches, 1986-1989, from fall DFO RV survey cruises.

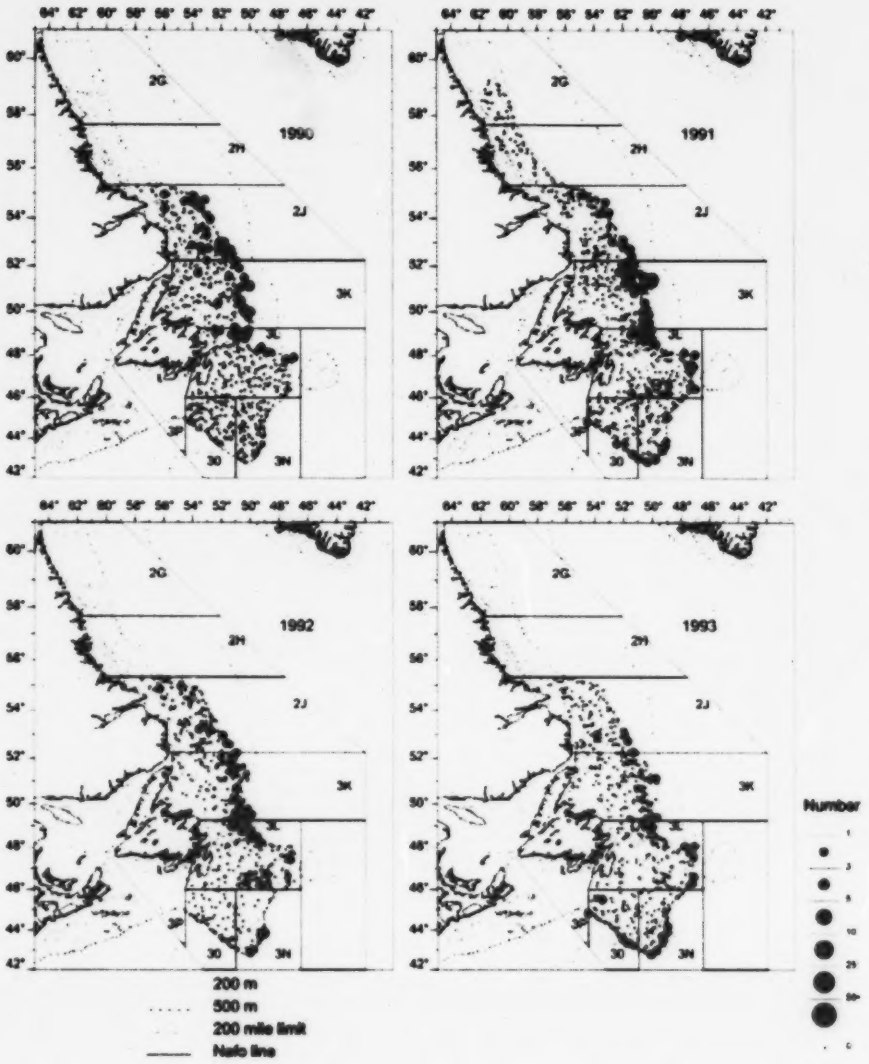

Figure 4d: Distribution of Northern wolffish catches, 1990-1993, from fall DFO RV survey cruises.

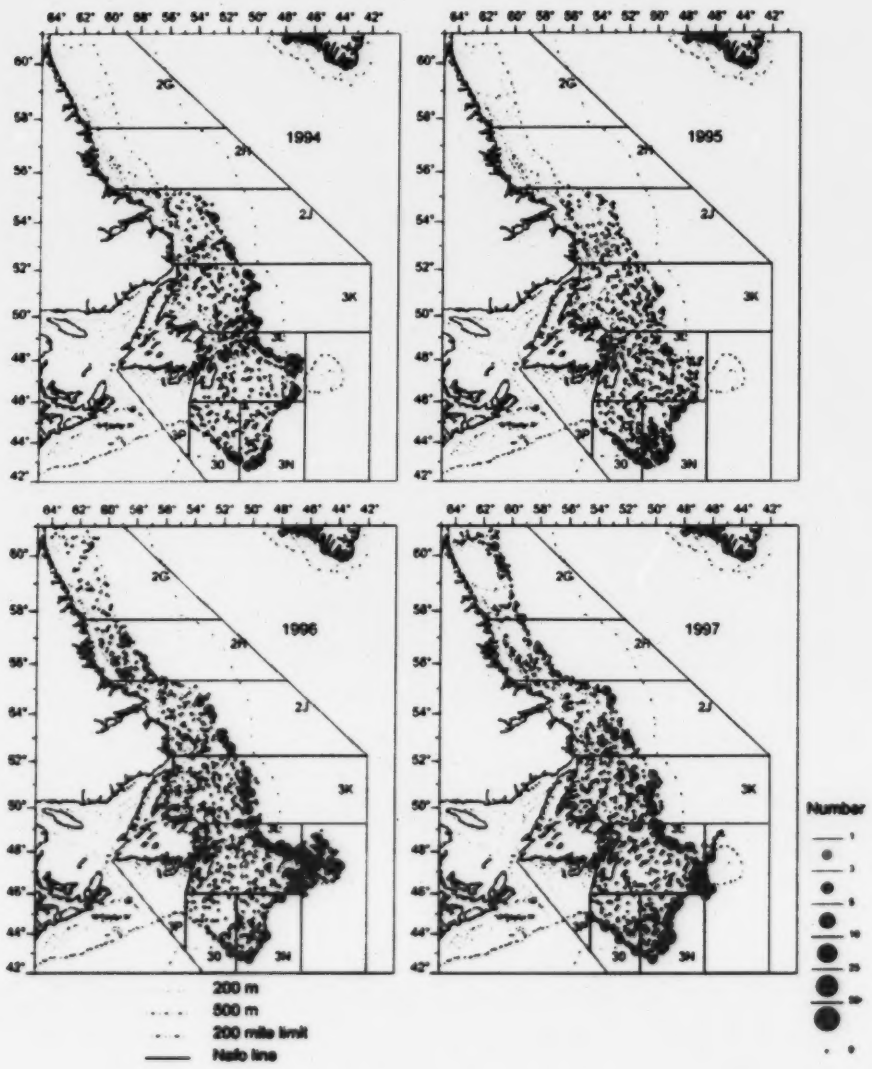

Figure 4e: Distribution of Northern wolffish catches, 1994-1997, from fall DFO RV survey cruises.

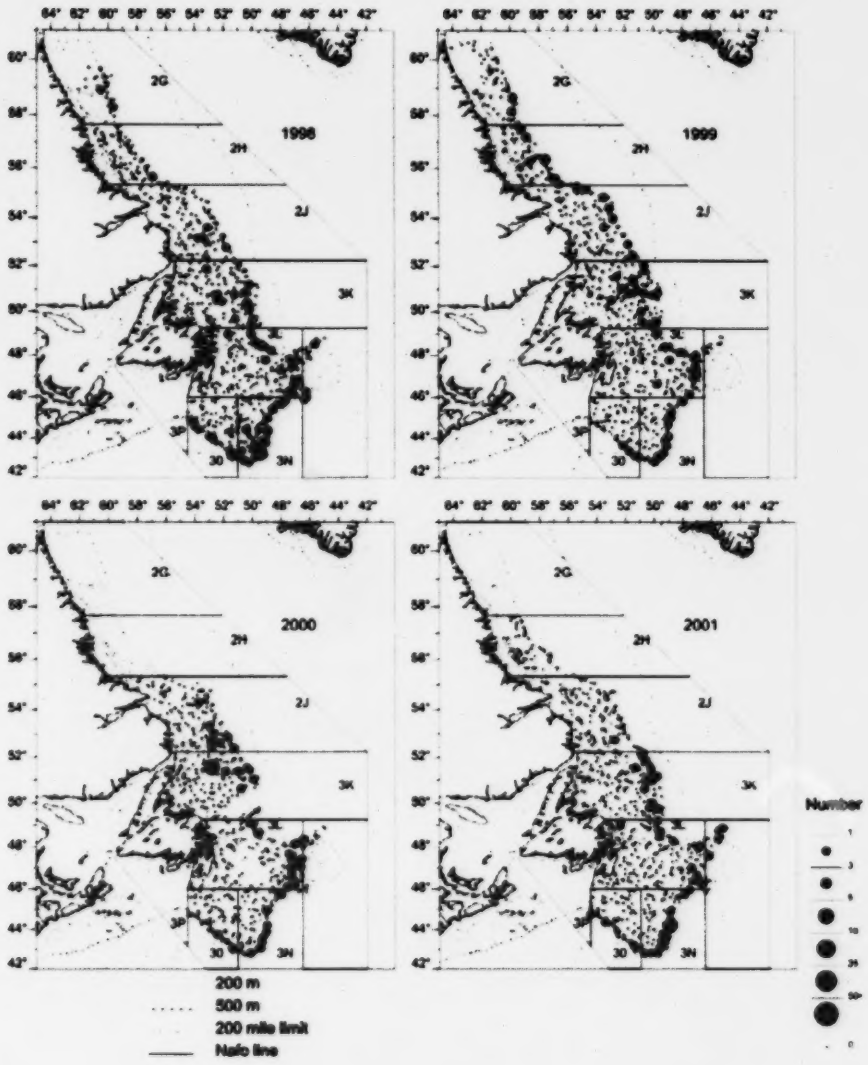

Figure 4f: Distribution of Northern wolffish catches, 1998-2001, from fall DFO RV survey cruises.

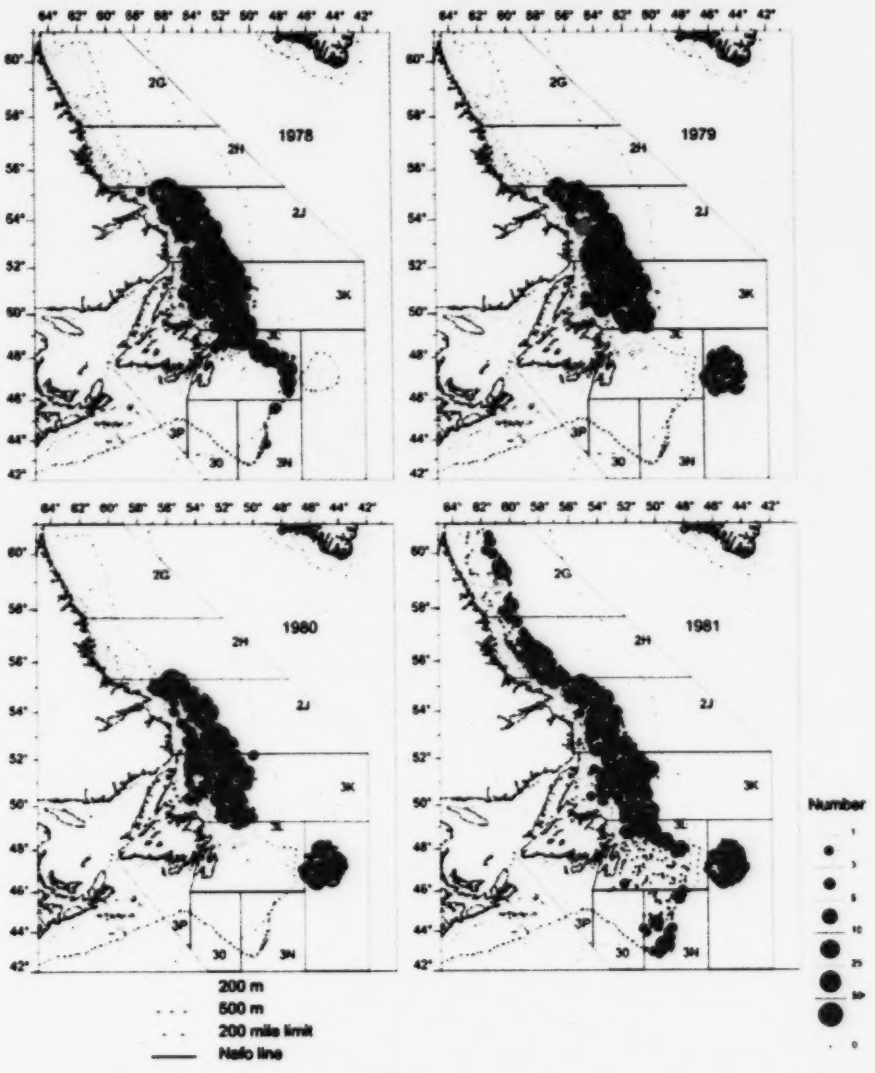

Figure 5a: Distribution of striped wolffish catches, 1978-1981, from fall DFO RV survey cruises.

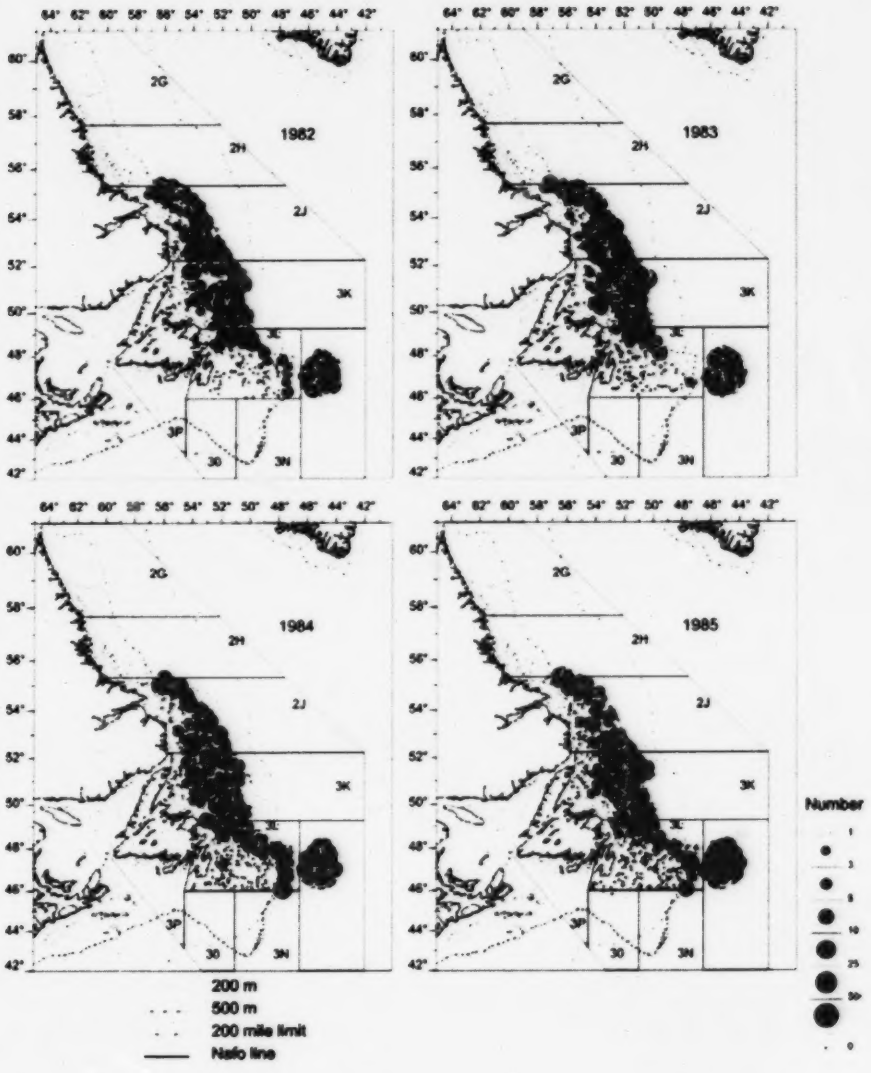

Figure 5b: Distribution of striped wolffish catches, 1982-1985, from fall DFO RV survey cruises.

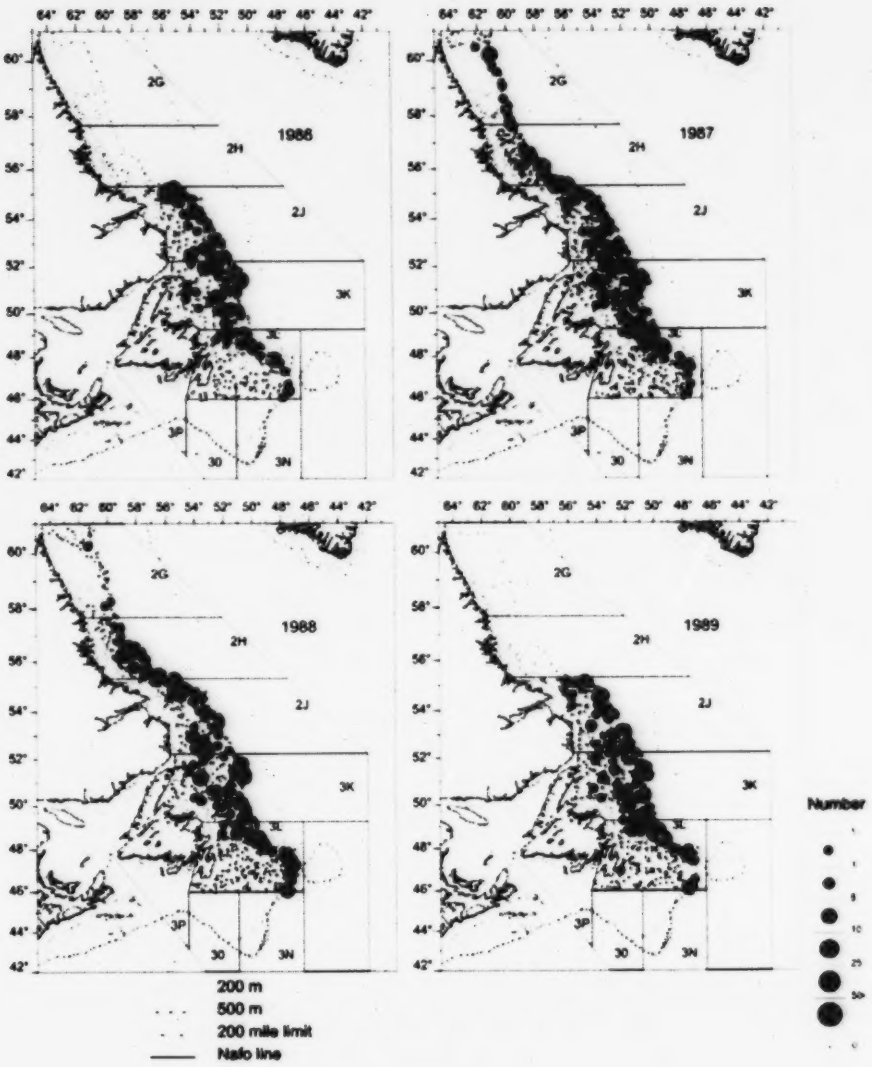

Figure 5c: Distribution of striped wolffish catches, 1986-1989, from fall DFO RV survey cruises.

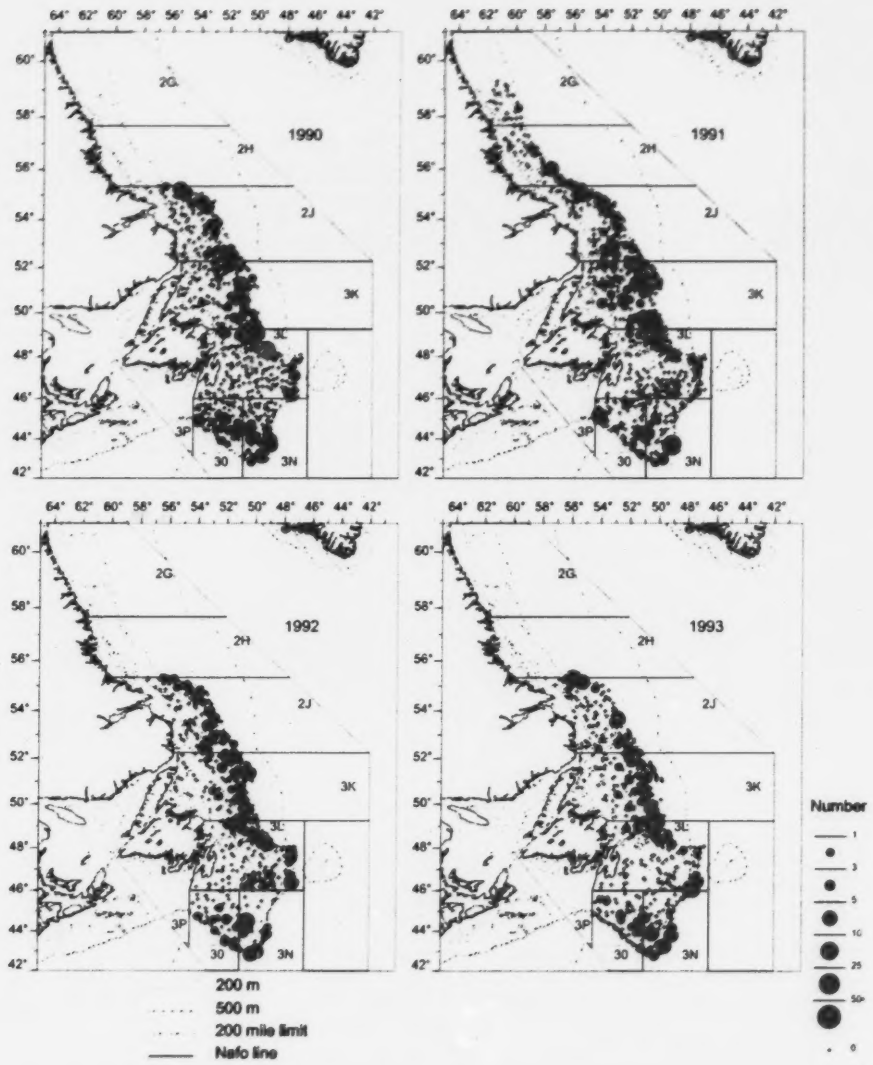

Figure 5d: Distribution of striped wolffish catches, 1990-1993, from fall DFO RV survey cruises.

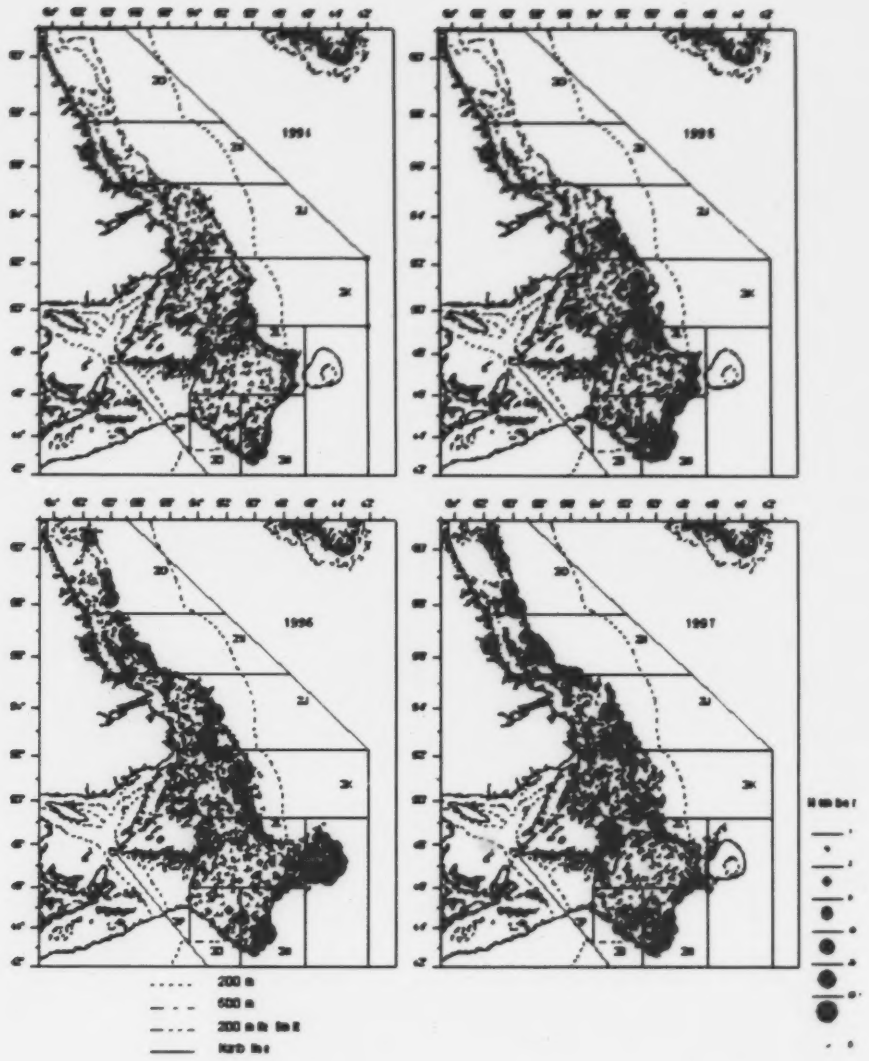

Figure 5e: Distribution of striped wolffish catches, 1994-1997, from fall DFO RV survey cruises.

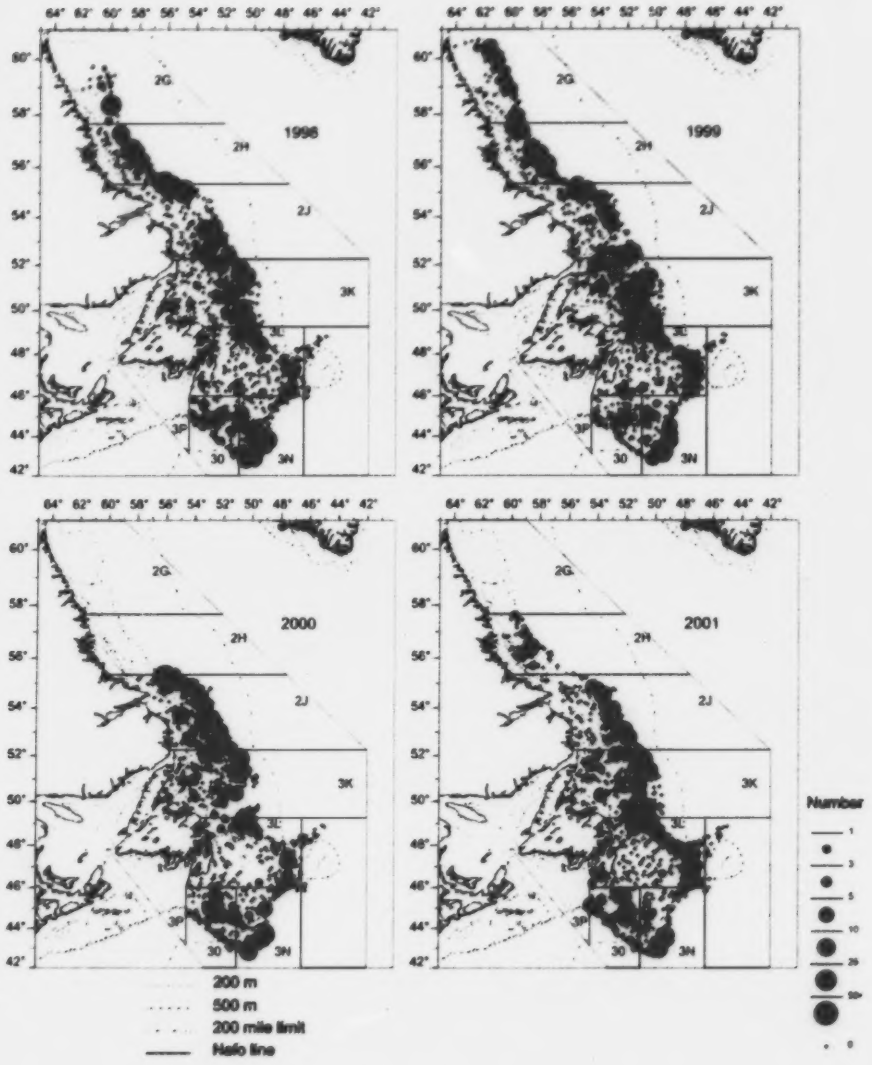

Figure 5f: Distribution of striped wolffish catches, 1998-2001, from fall DFO RV survey cruises.

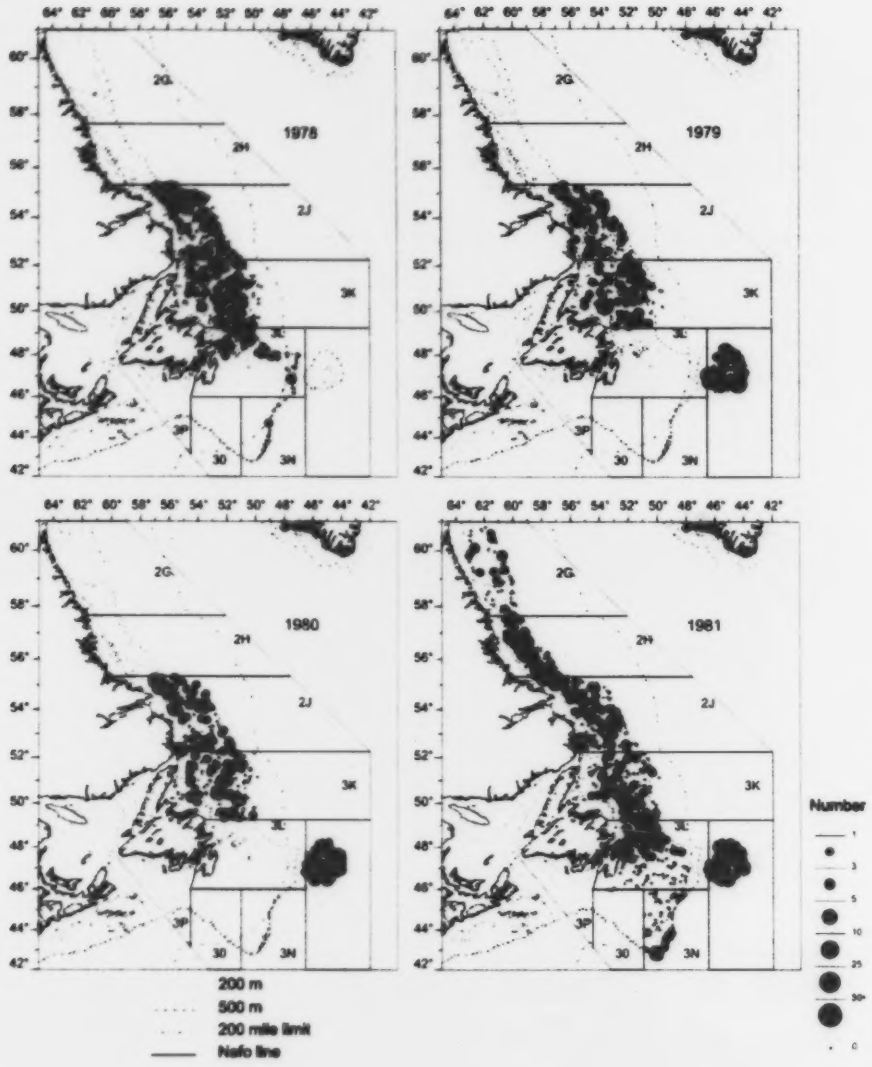

Figure 6a: Distribution of spotted wolffish catches, 1978-1981, from fall DFO RV survey cruises.

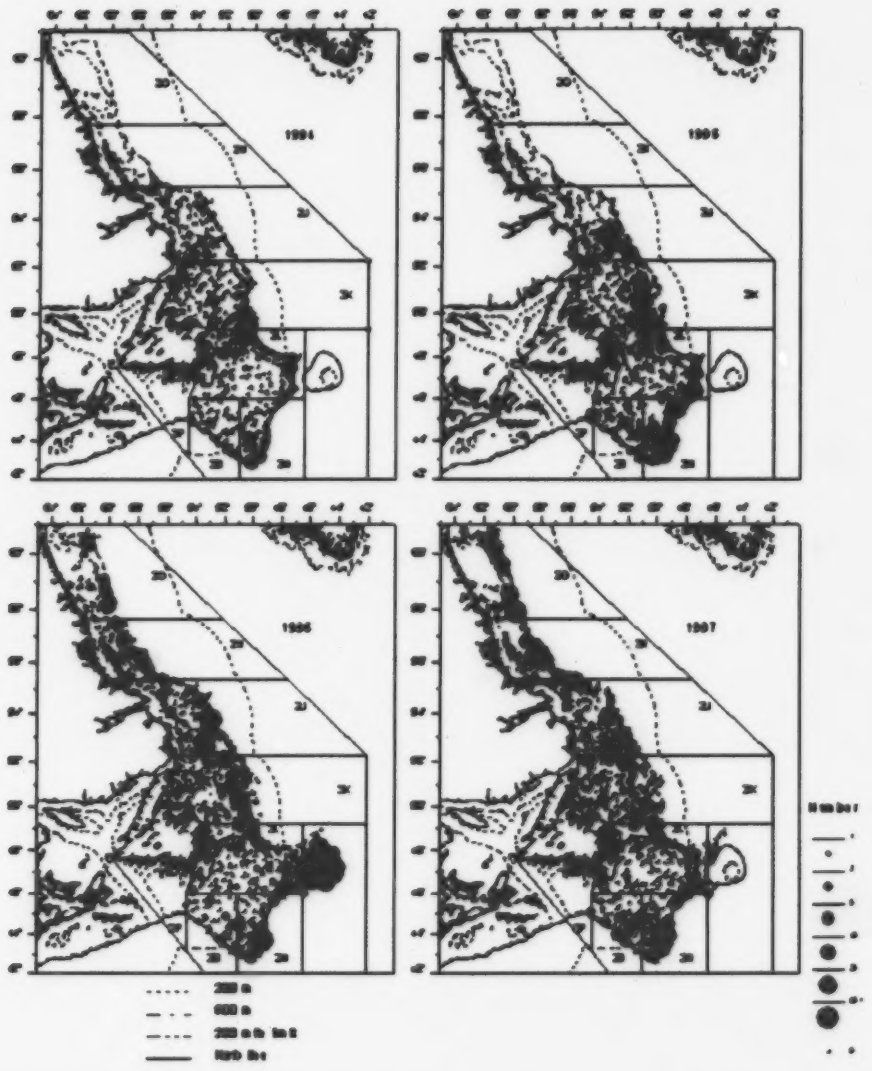

Figure 6b: Distribution of spotted wolffish catches, 1982-1985, from fall DFO RV survey cruises.

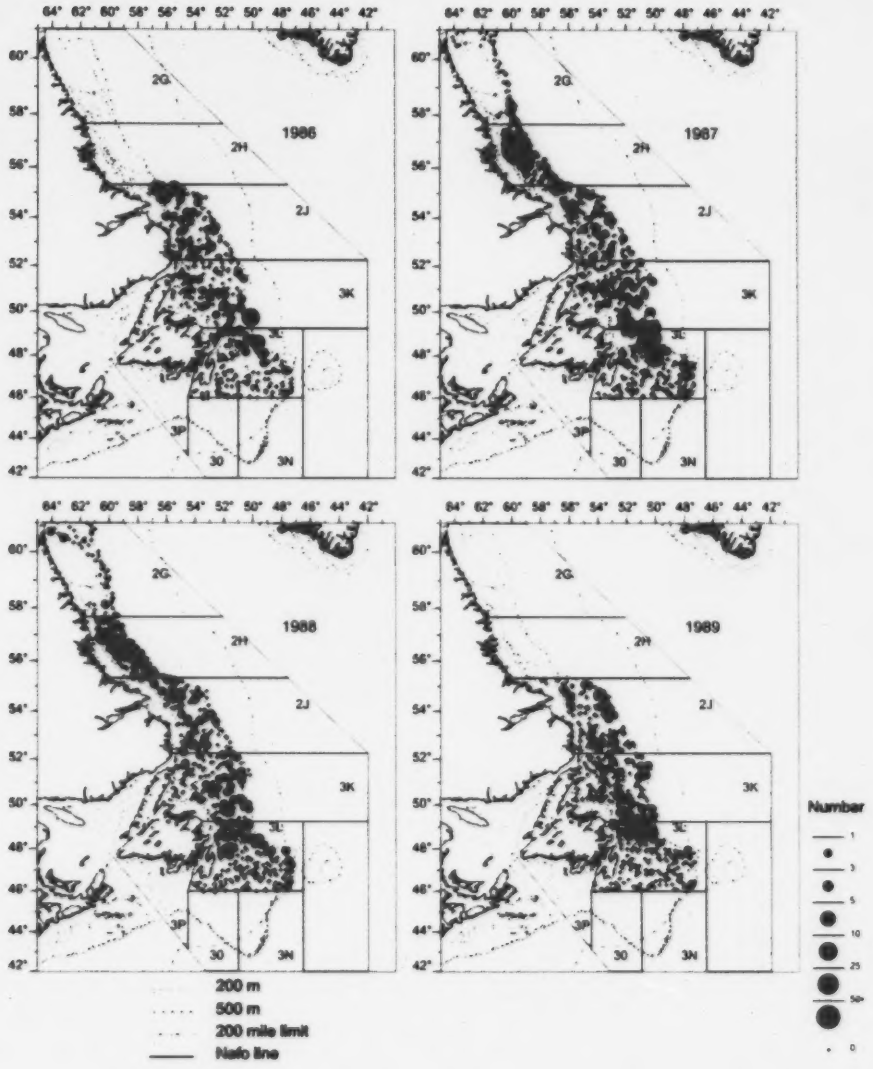

Figure 6c: Distribution of spotted wolffish catches, 1986-1989, from fall DFO RV survey cruises.

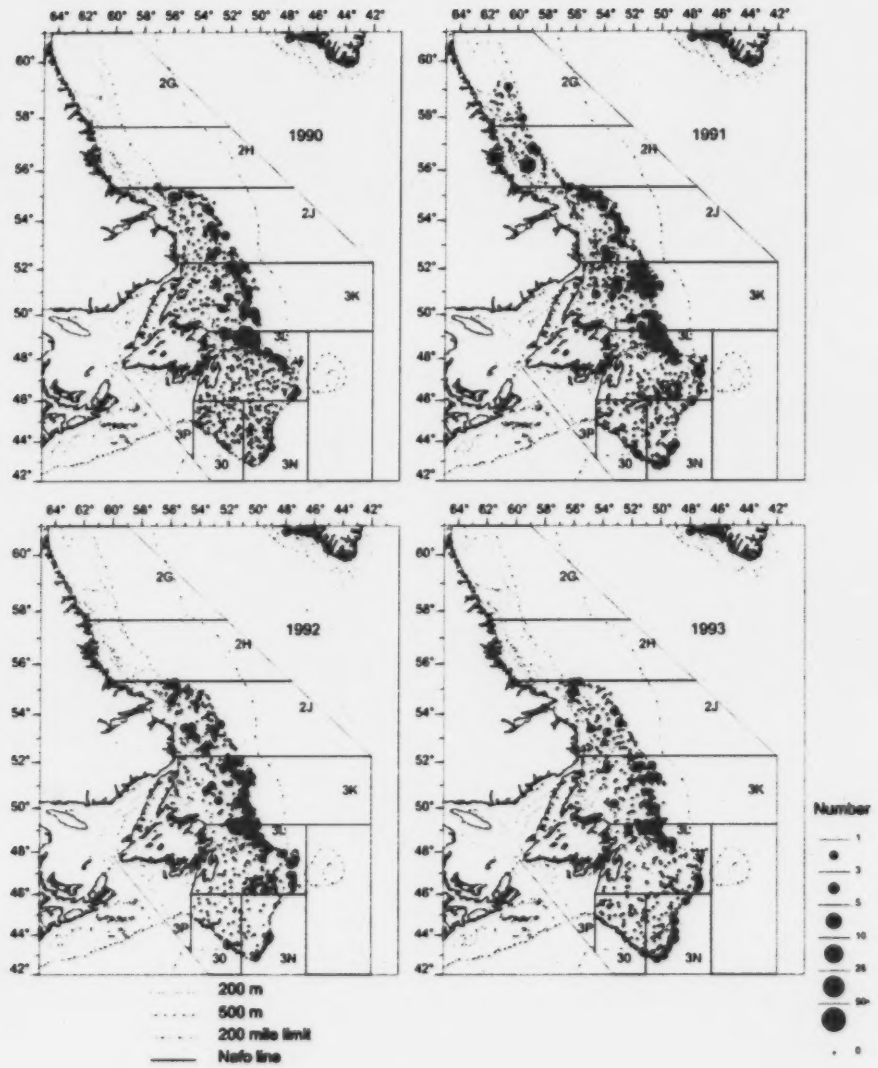

Figure 6d: Distribution of spotted wolffish catches, 1990-1993, from fall DFO RV survey cruises.

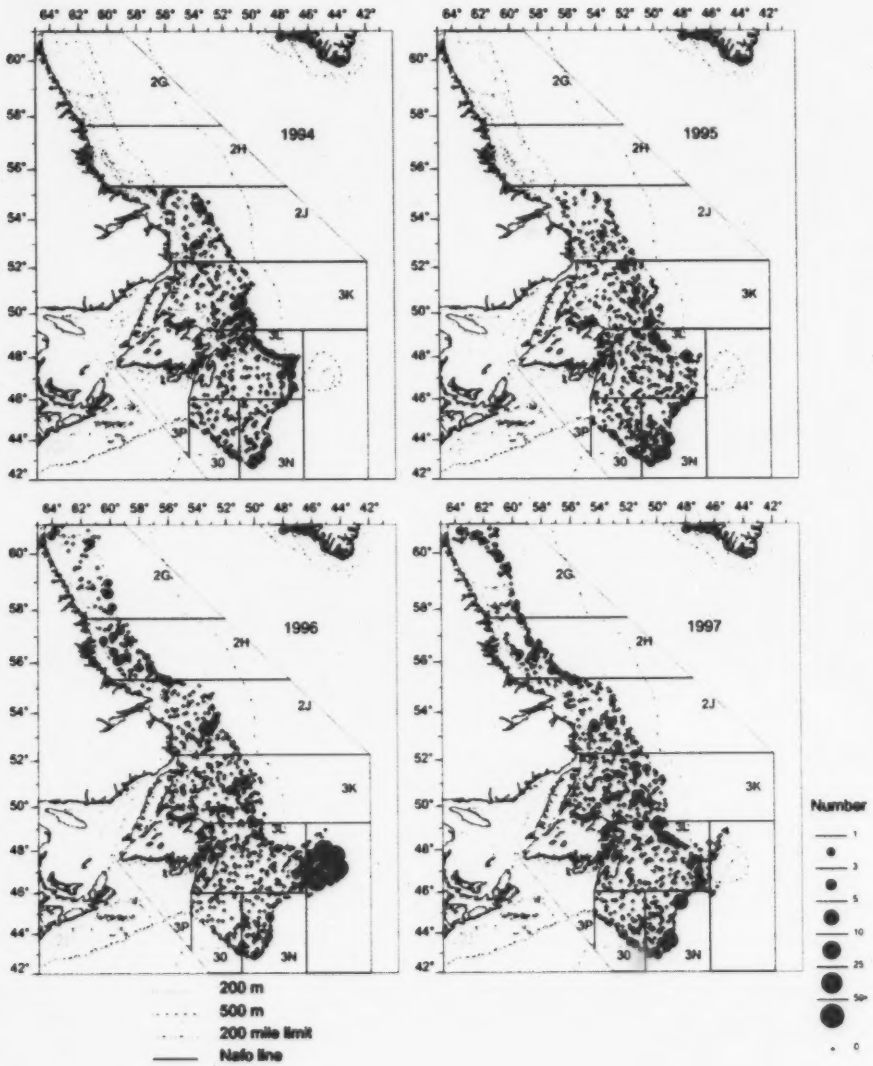

Figure 6e: Distribution of spotted wolffish catches, 1994-1997, from fall DFO RV survey cruises.

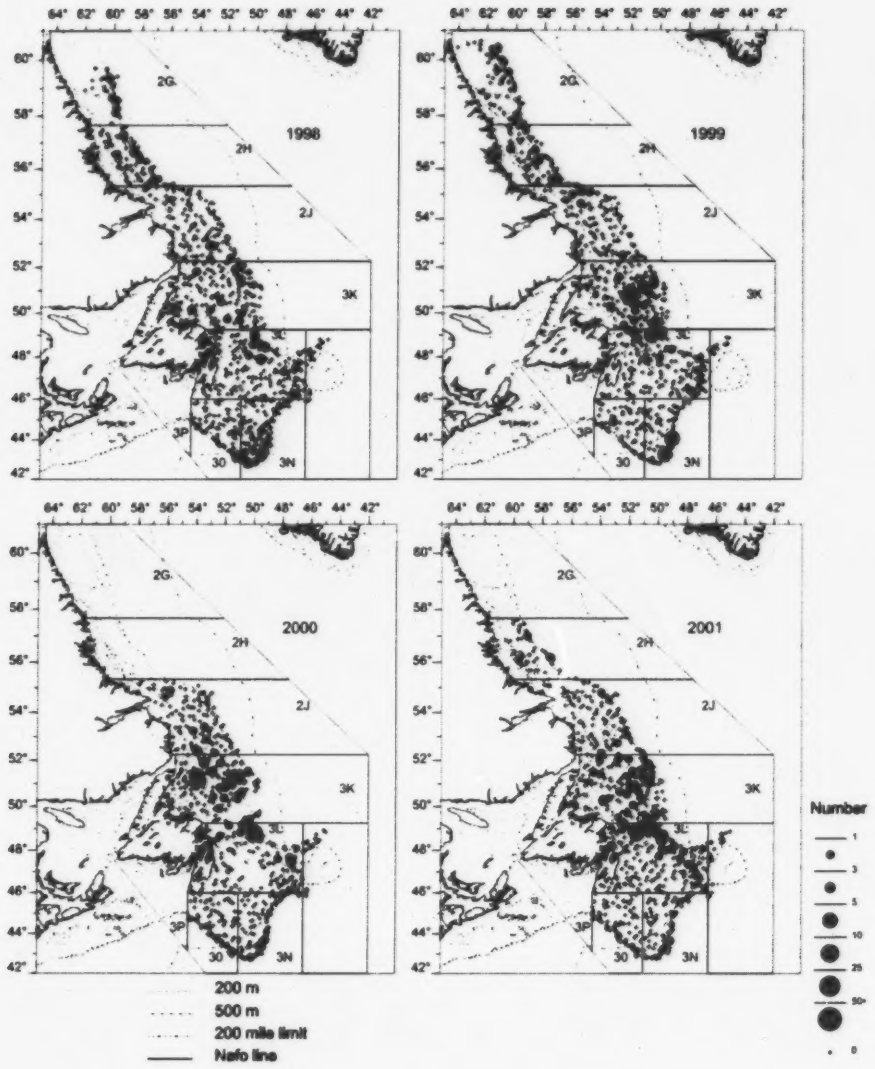

Figure 6f: Distribution of spotted wolffish catches, 1998-2001, from fall DFO RV survey cruises.

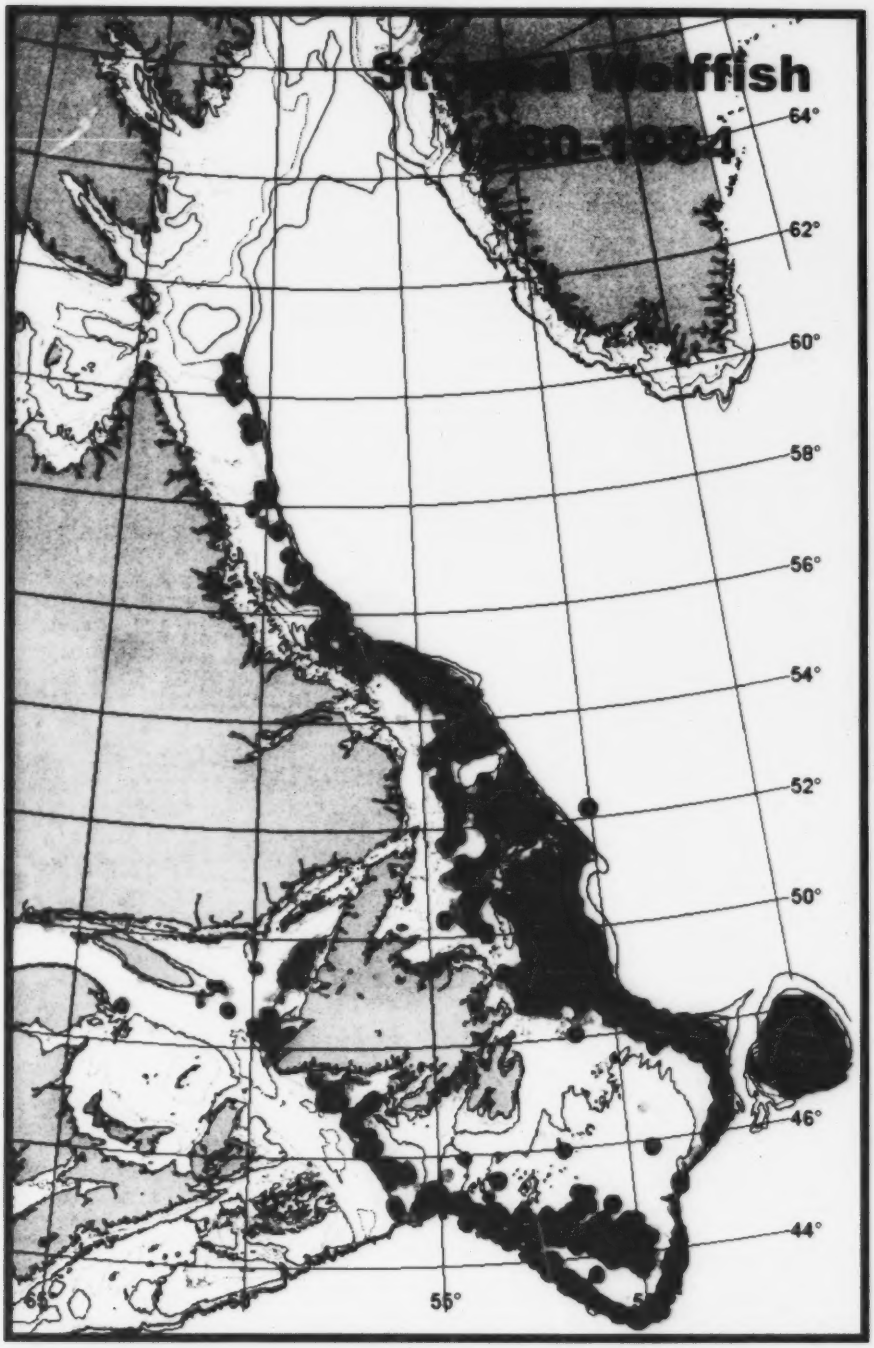

Figure 7a. Distribution of Striped Wolffish, 1980-1984.

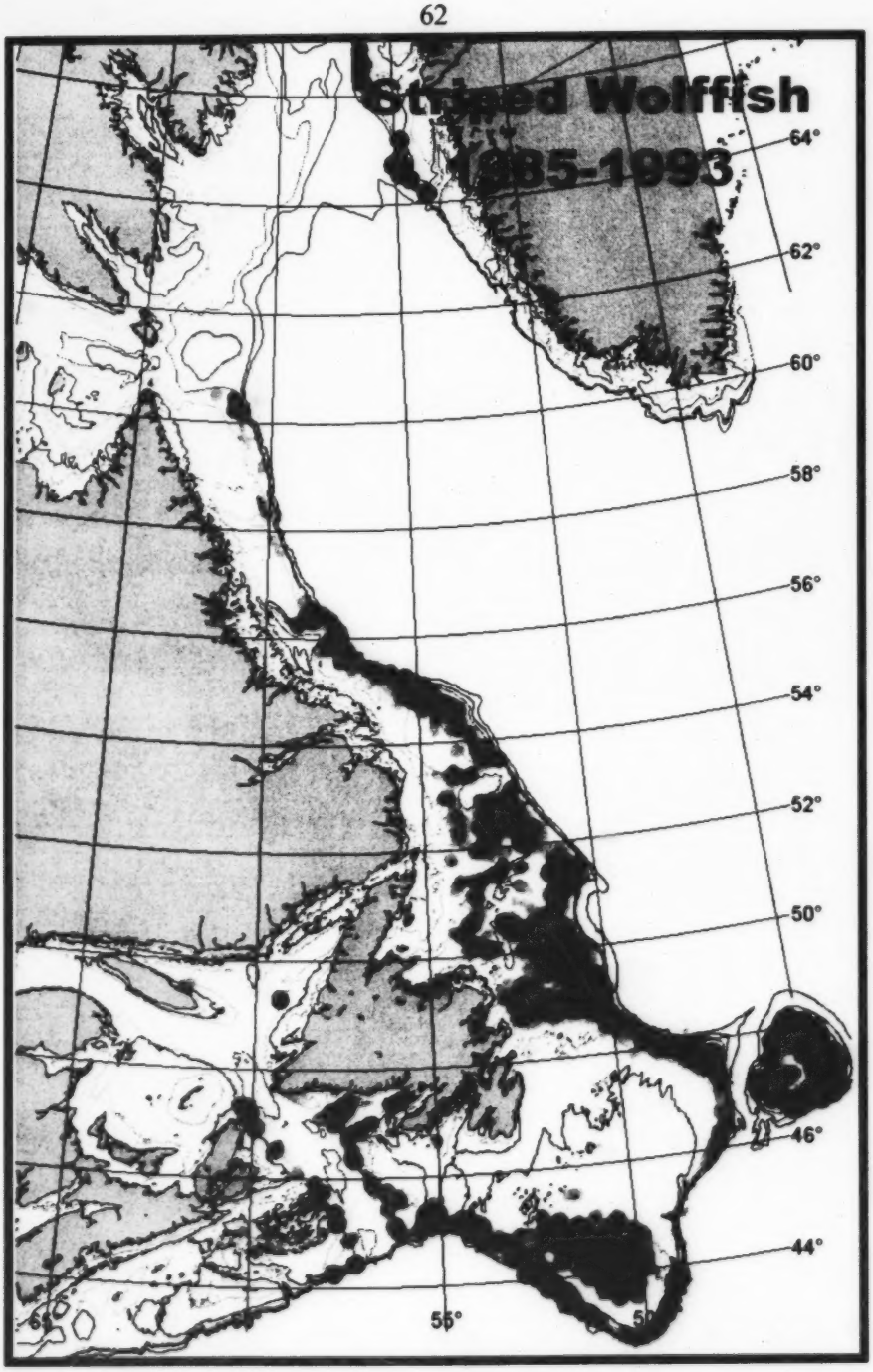

Figure 7b. Distribution of Striped Wolffish, 1985-1993.

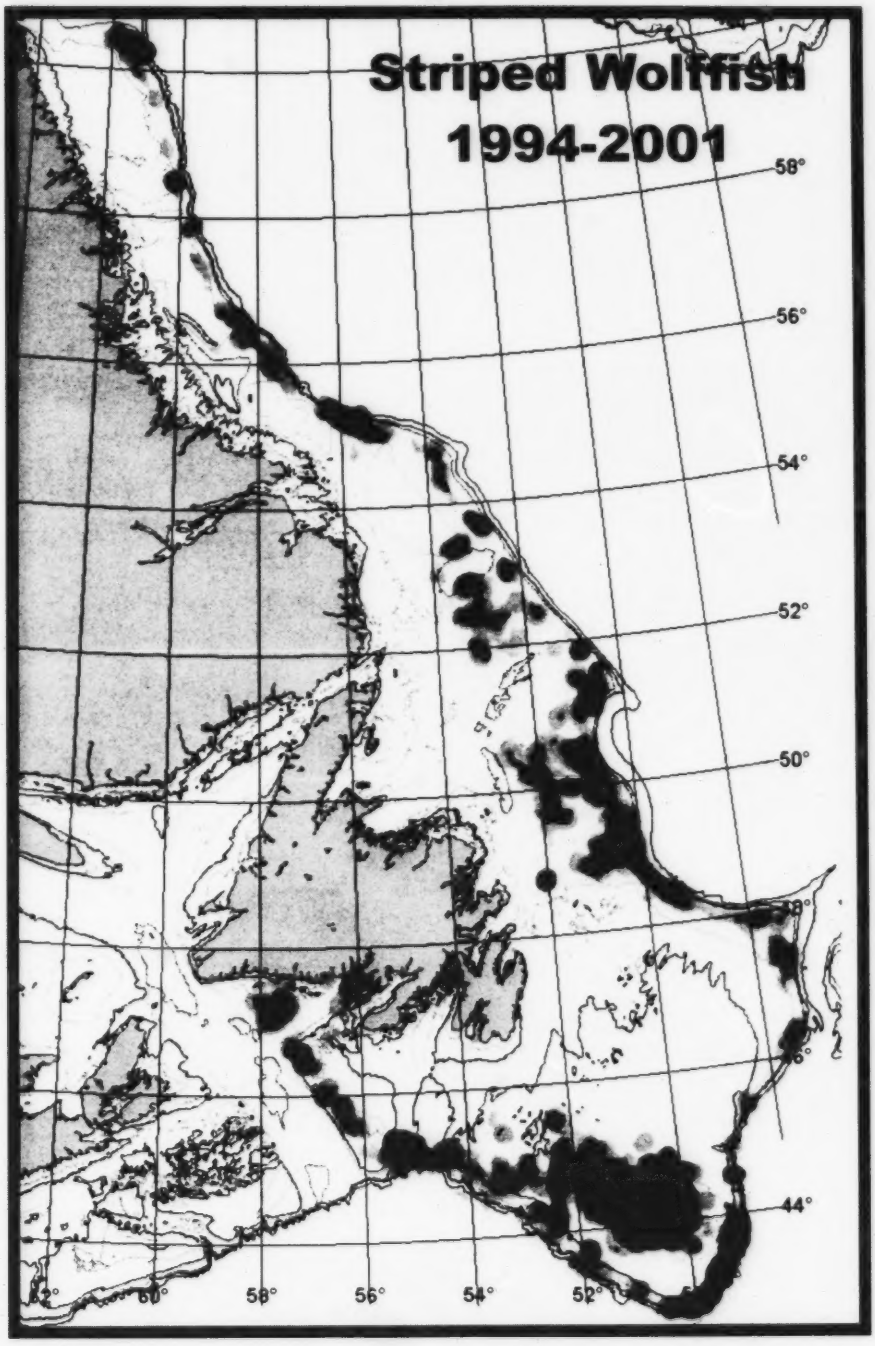

Figure 7c. Distribution of Striped Wolffish, 1994-2001.

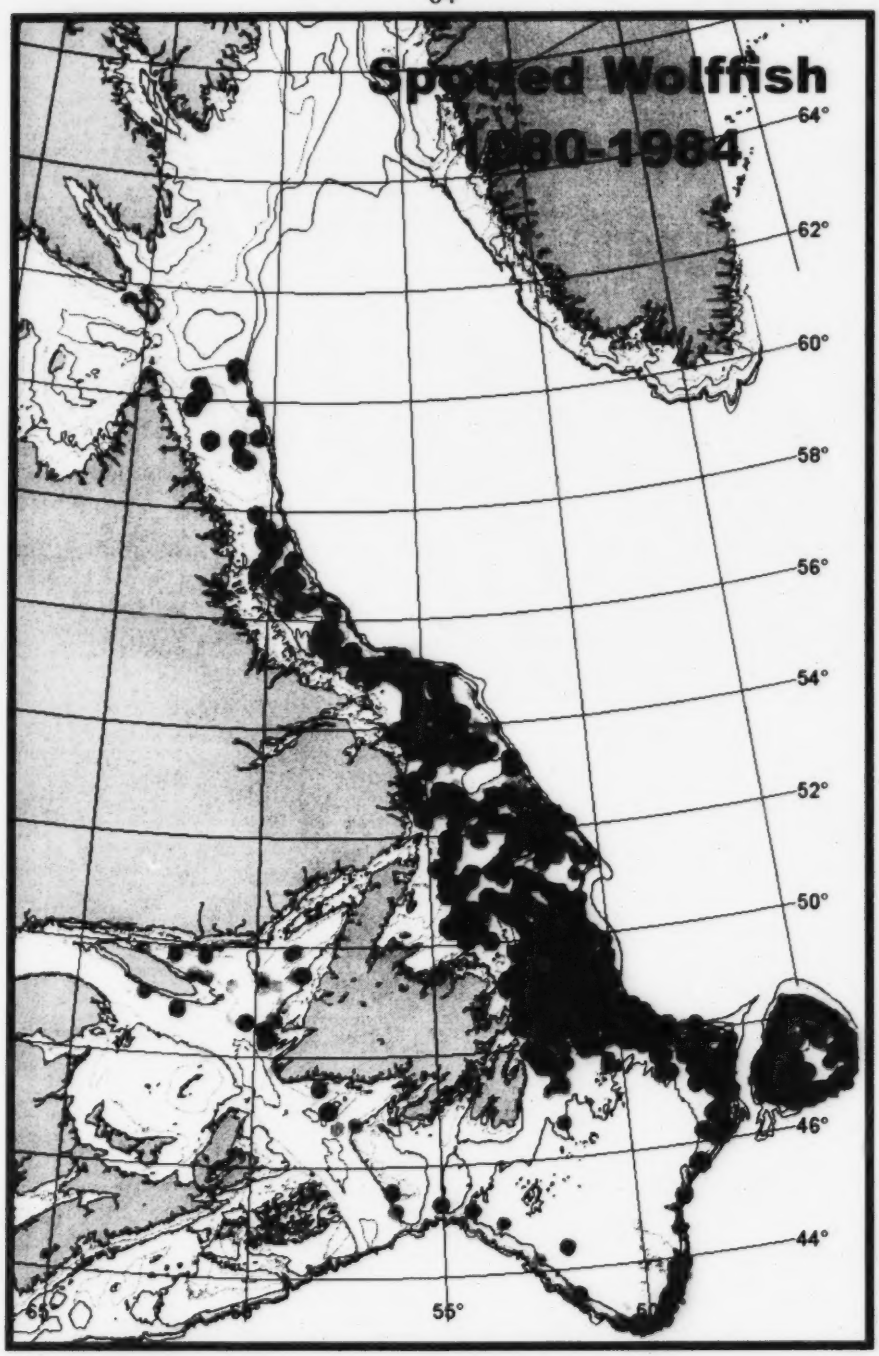

Figure 8a. Distribution of Spotted Wolffish, 1980-1984.

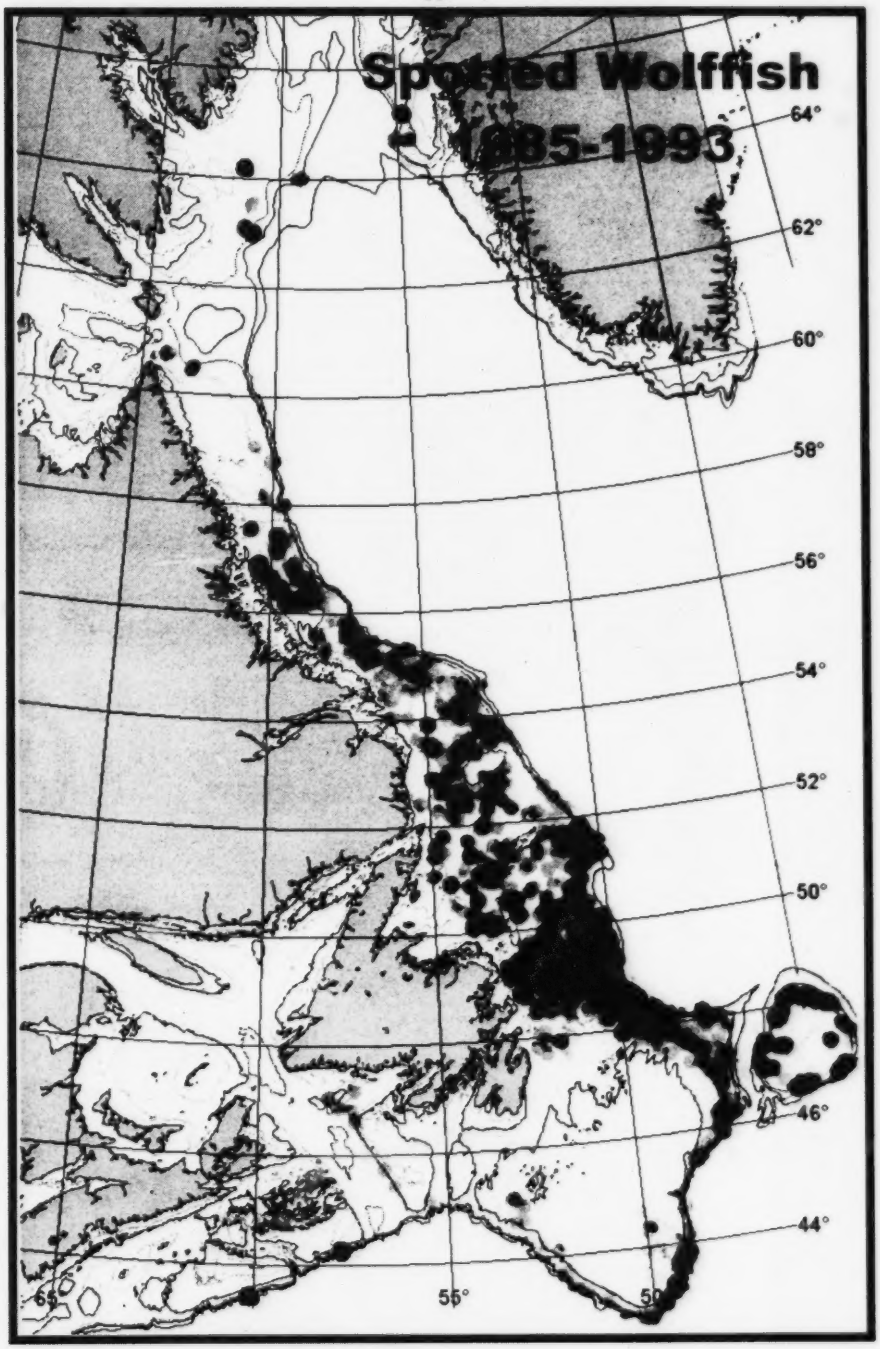

Figure 8b. Distribution of Spotted Wolffish, 1985-1993.

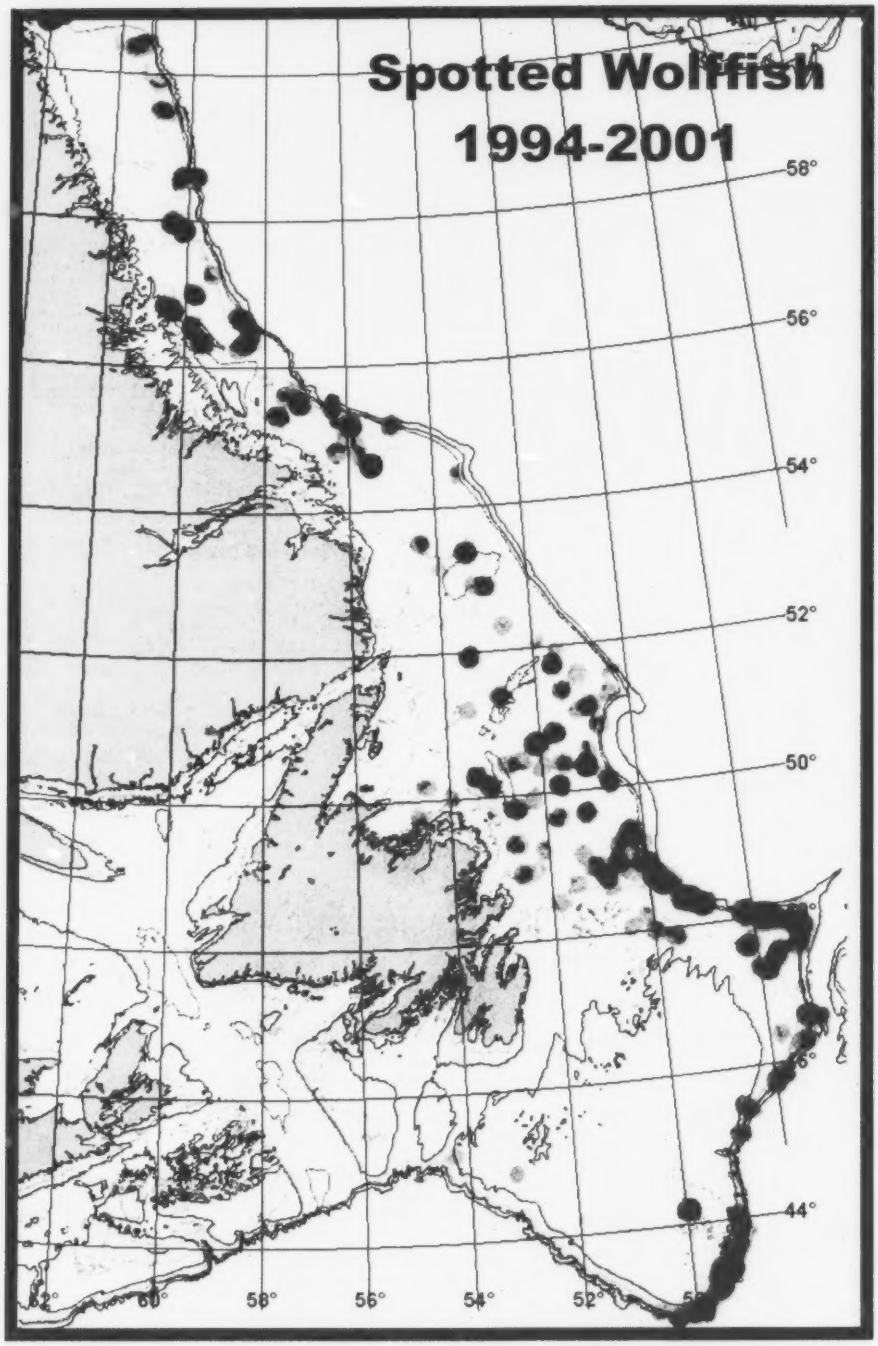

Figure 8c. Distribution of Spotted Wolffish, 1994-2001.

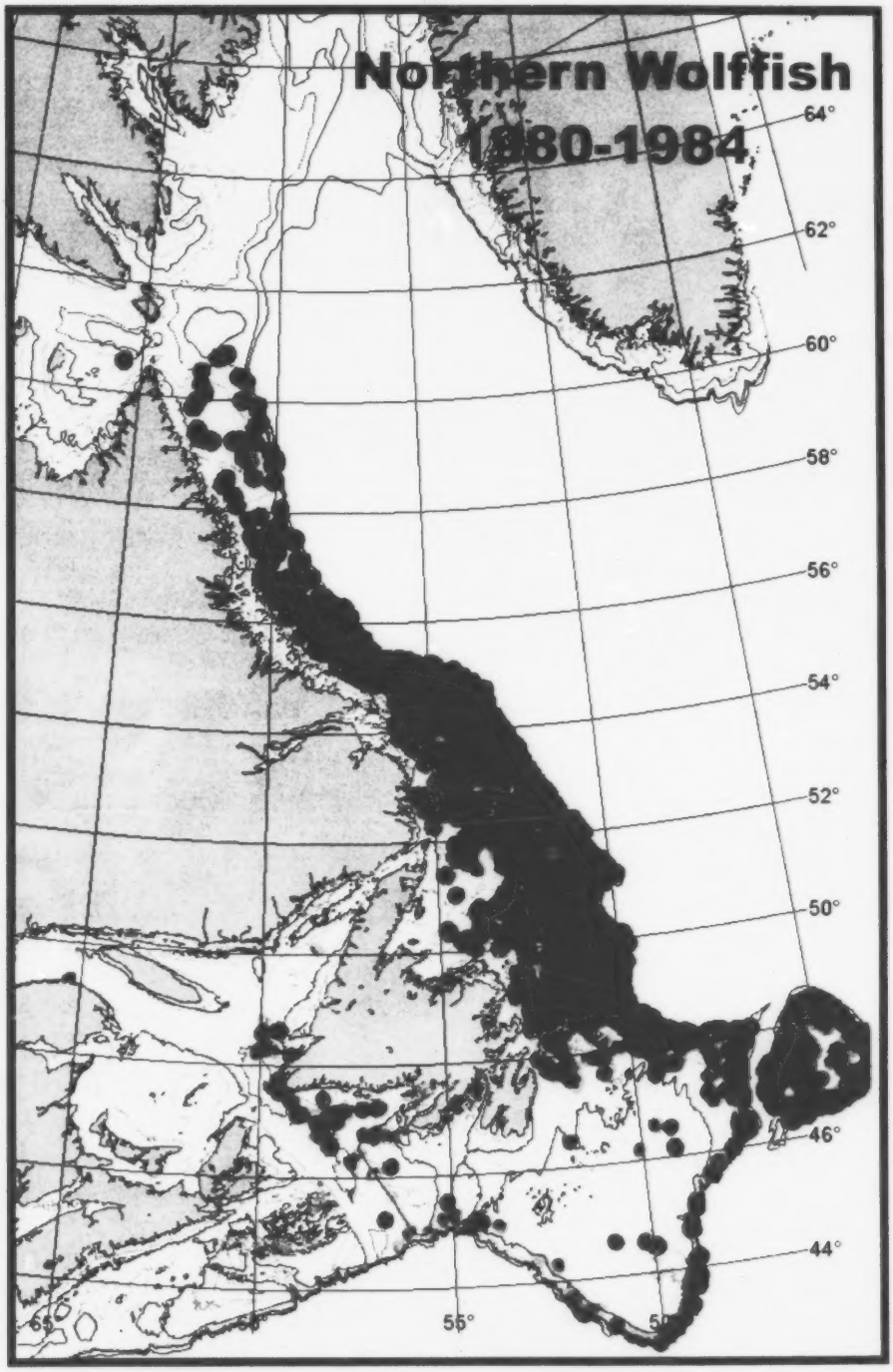

Figure 9a. Distribution of Northern Wolffish, 1980-1984.

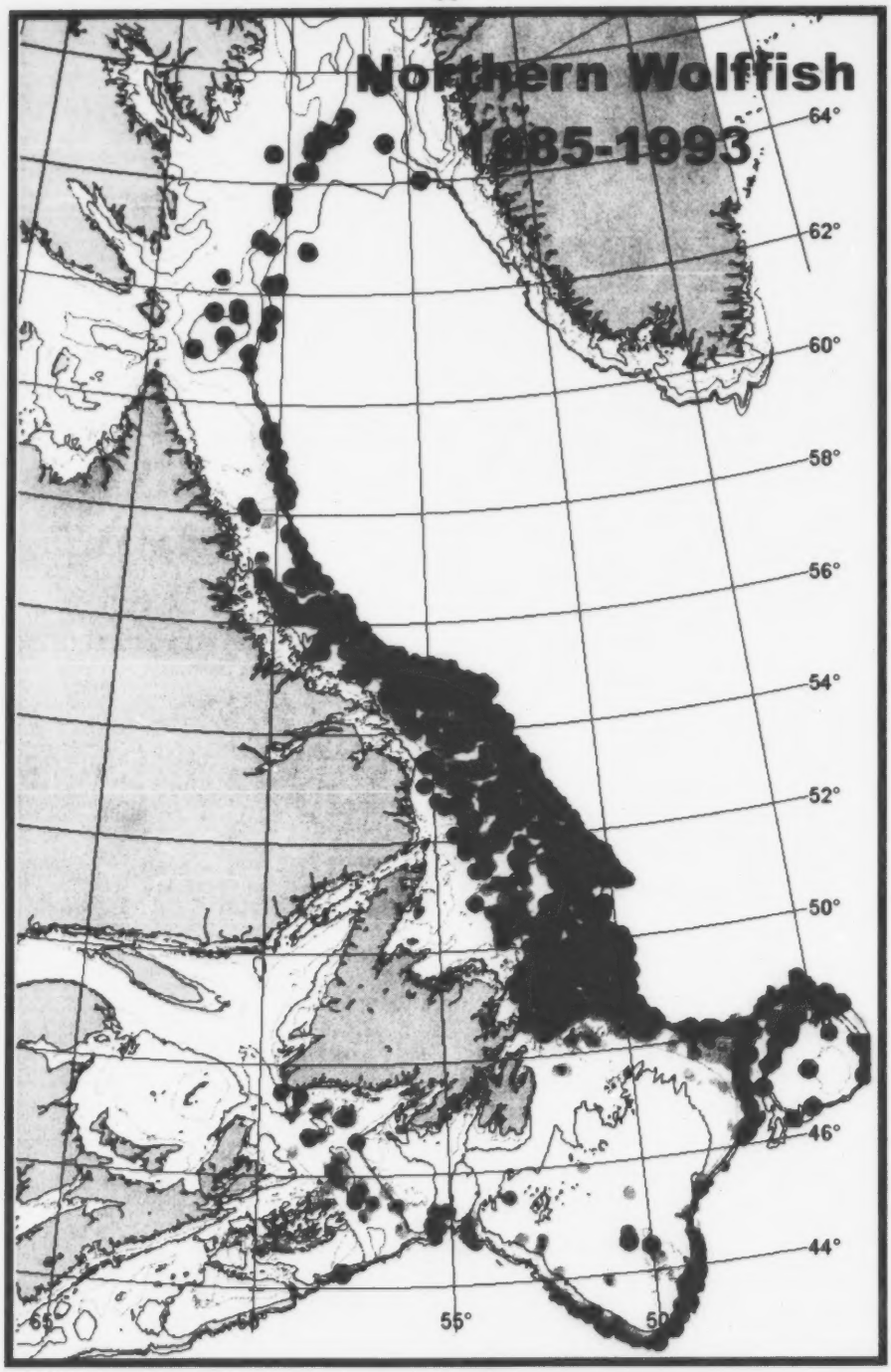

Figure 9b. Distribution of Northern Wolffish, 1985-1993.

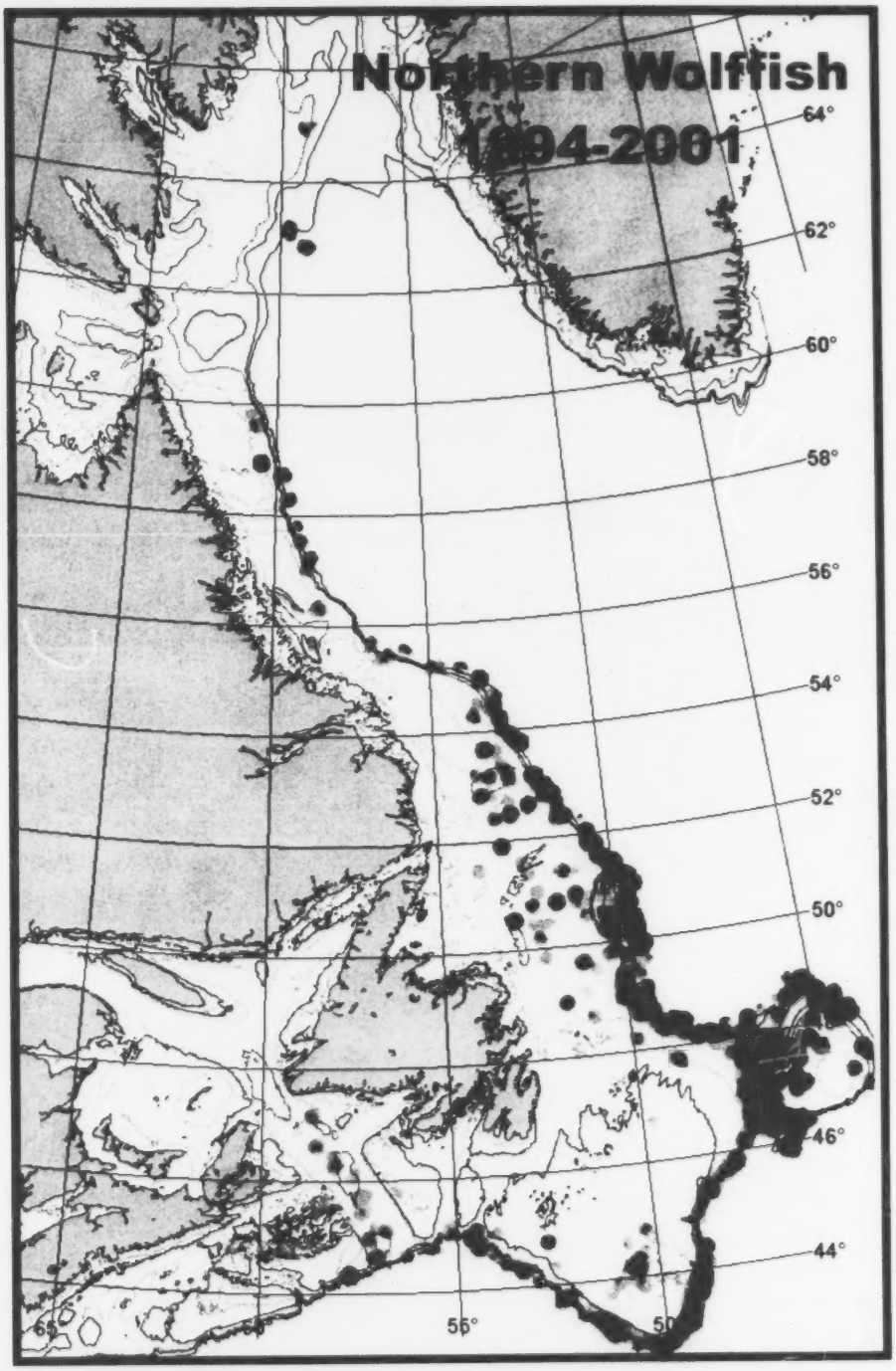

Figure 9c. Distribution of Northern Wolffish, 1985-1993.

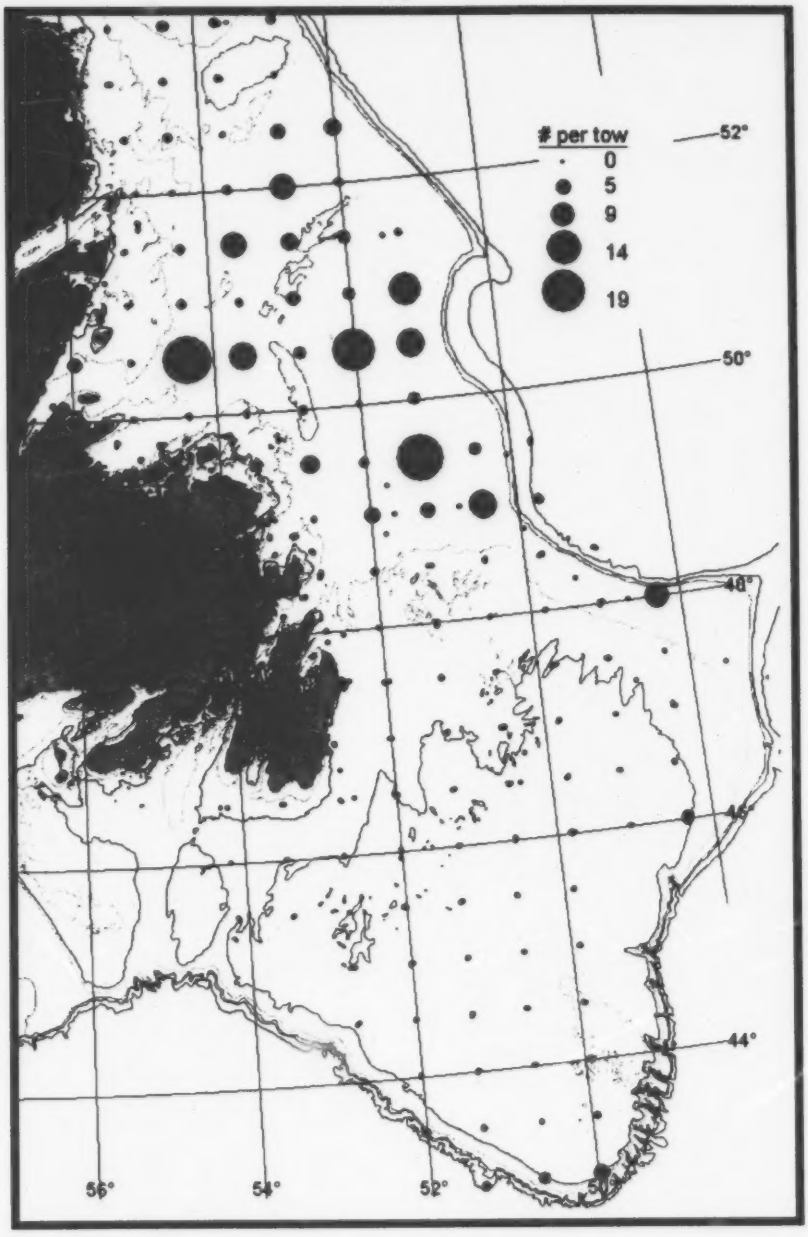

Figure 10. Distribution of young of the year striped wolffish taken during 1996-1999 (Aug. Sept.) using IYGPT trawl gear. Larger circles show areas of highest concentration.

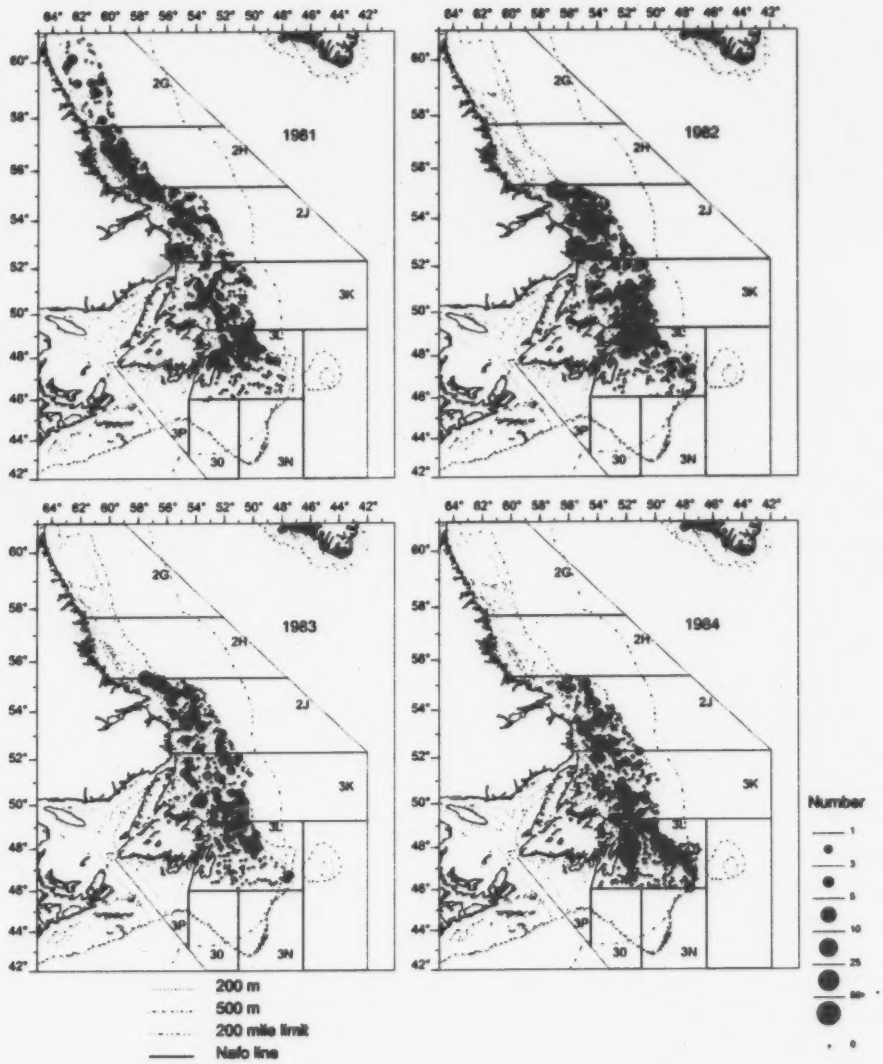

Figure 11a: Distribution of spotted wolffish GREATER than 55cm in length captured in fall DFO surveys, 1981-1984.

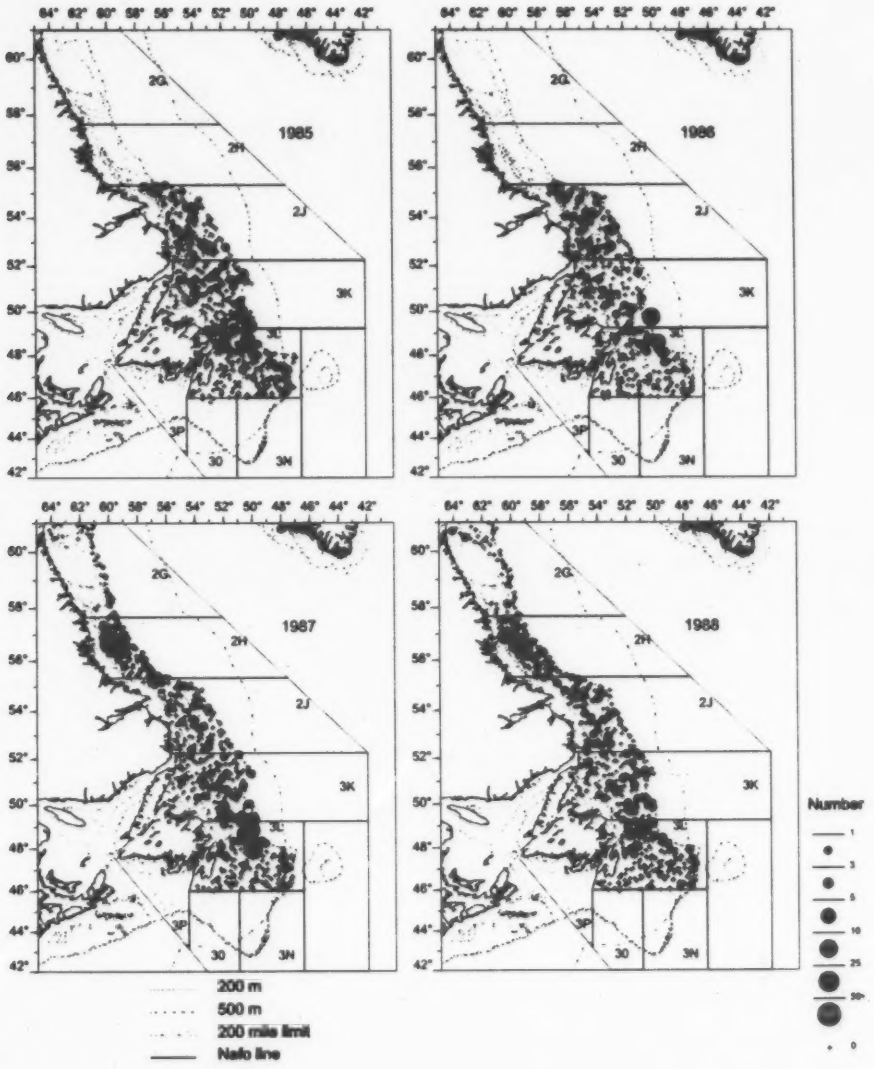

Figure 11b: Distribution of spotted wolffish GREATER than 55cm in length captured in fall DFO surveys, 1985-1988.

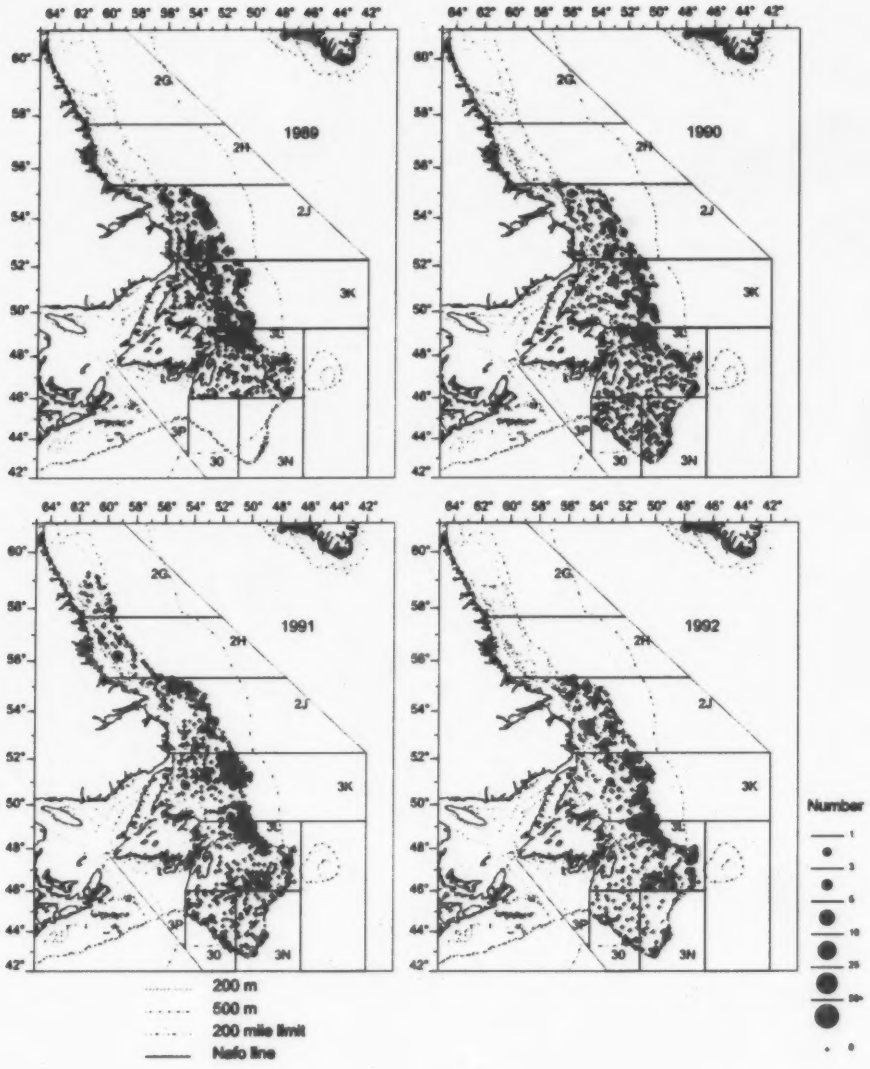

Figure 11c: Distribution of spotted wolffish GREATER than 55cm in length captured in fall DFO surveys, 1989-1992.

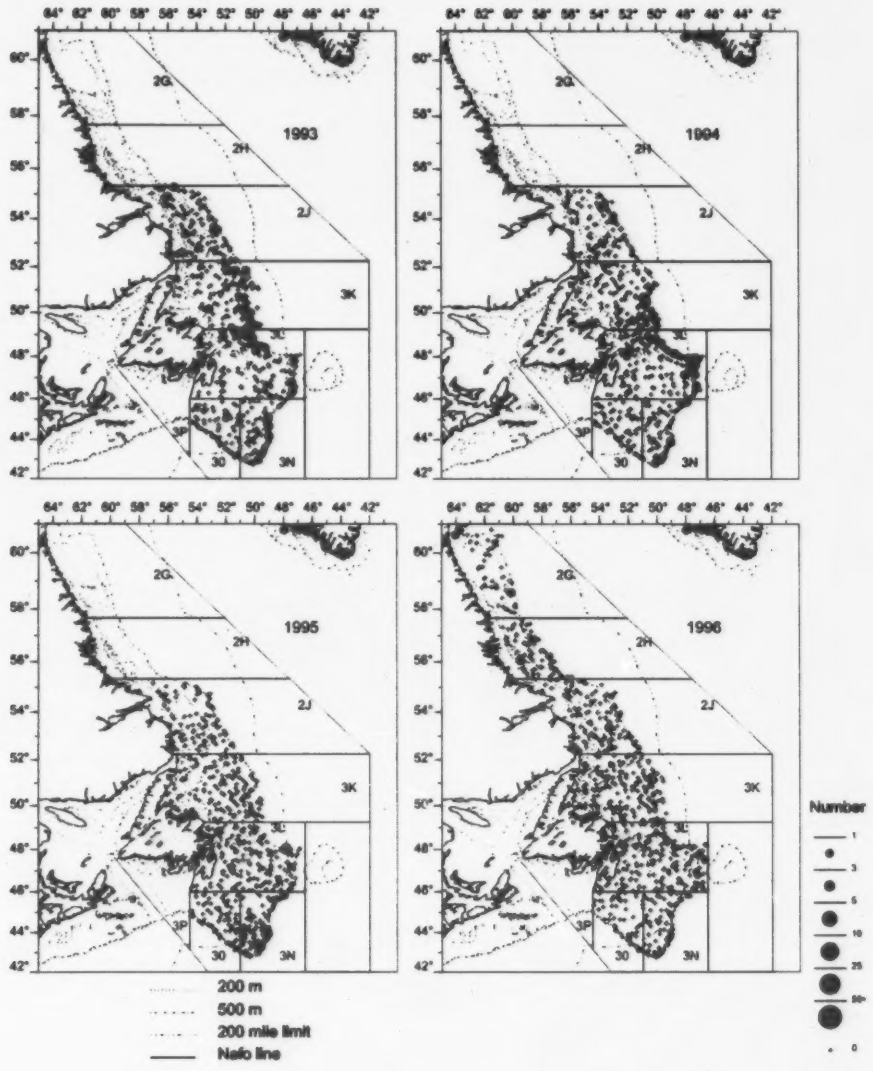

Figure 11d: Distribution of spotted wolffish GREATER than 55cm in length captured in fall DFO surveys, 1993-1996.

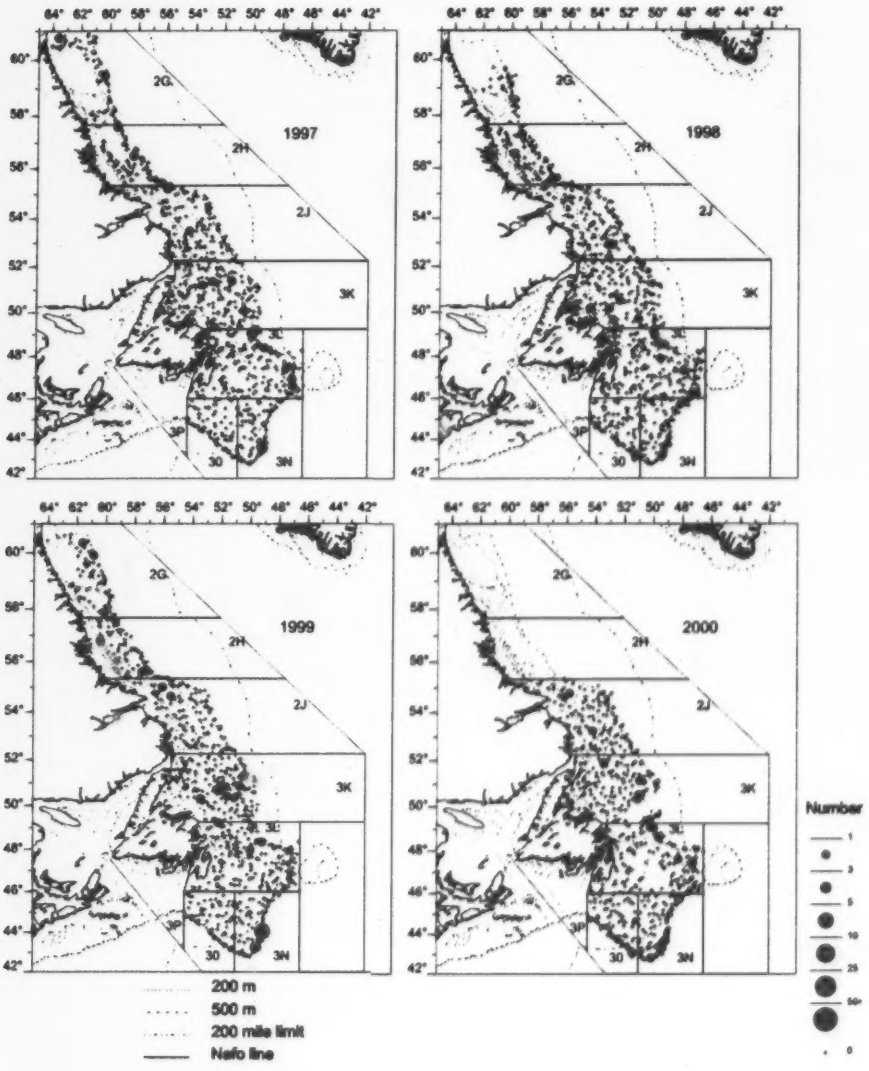

Figure 11e: Distribution of spotted wolffish GREATER than 55cm in length captured in fall DFO surveys, 1997-2000.

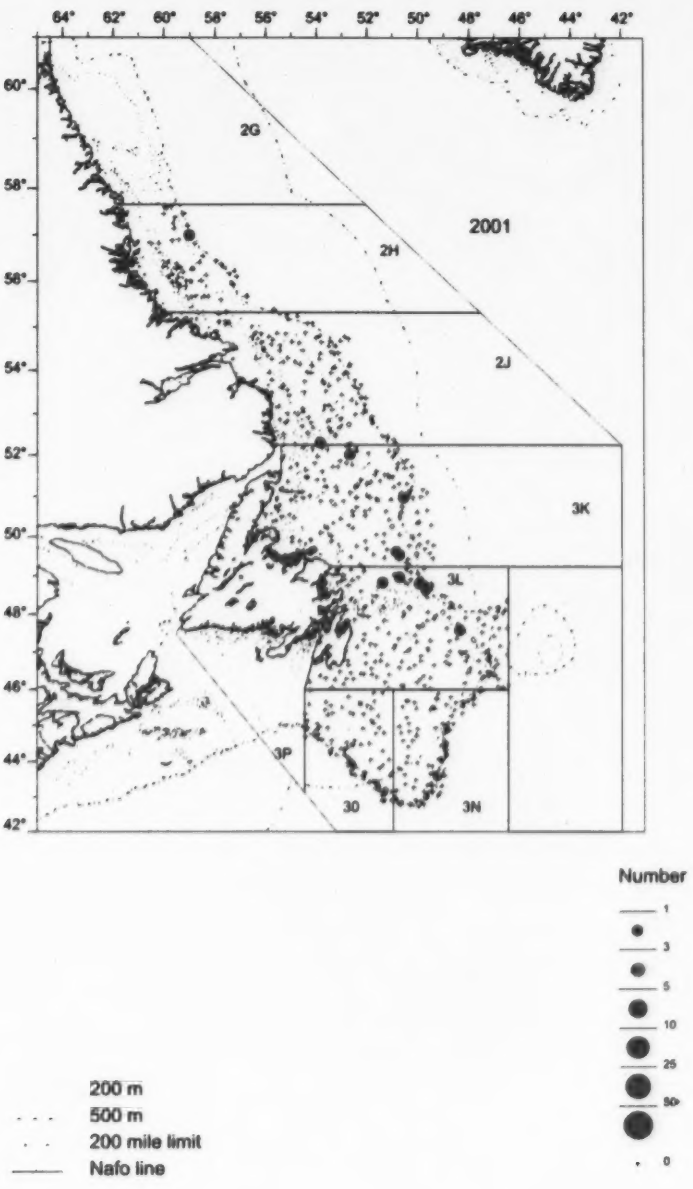

Figure 11f: Distribution of spotted wolffish GREATER than 55cm in length captured in fall DFO surveys, 2001.

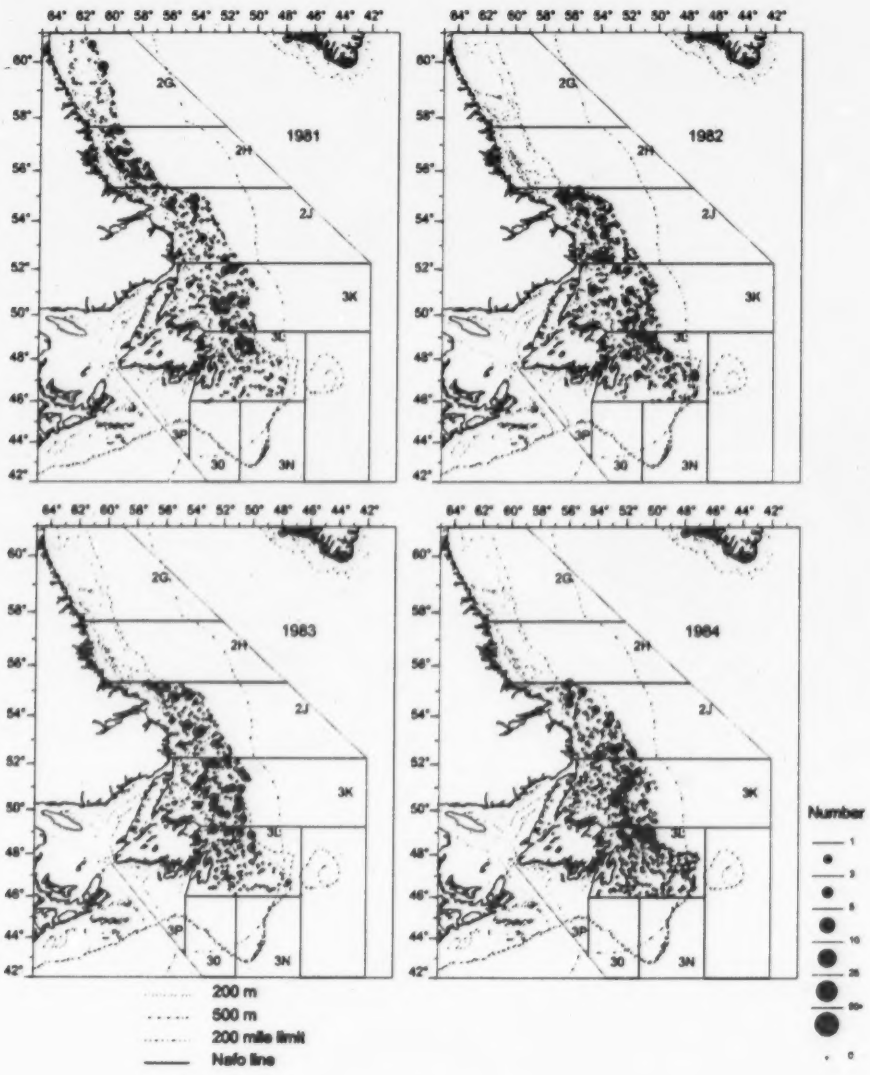

Figure 12a: Distribution of spotted wolffish LESS than 55cm in length captured in fall DFO surveys, 1981-1984.

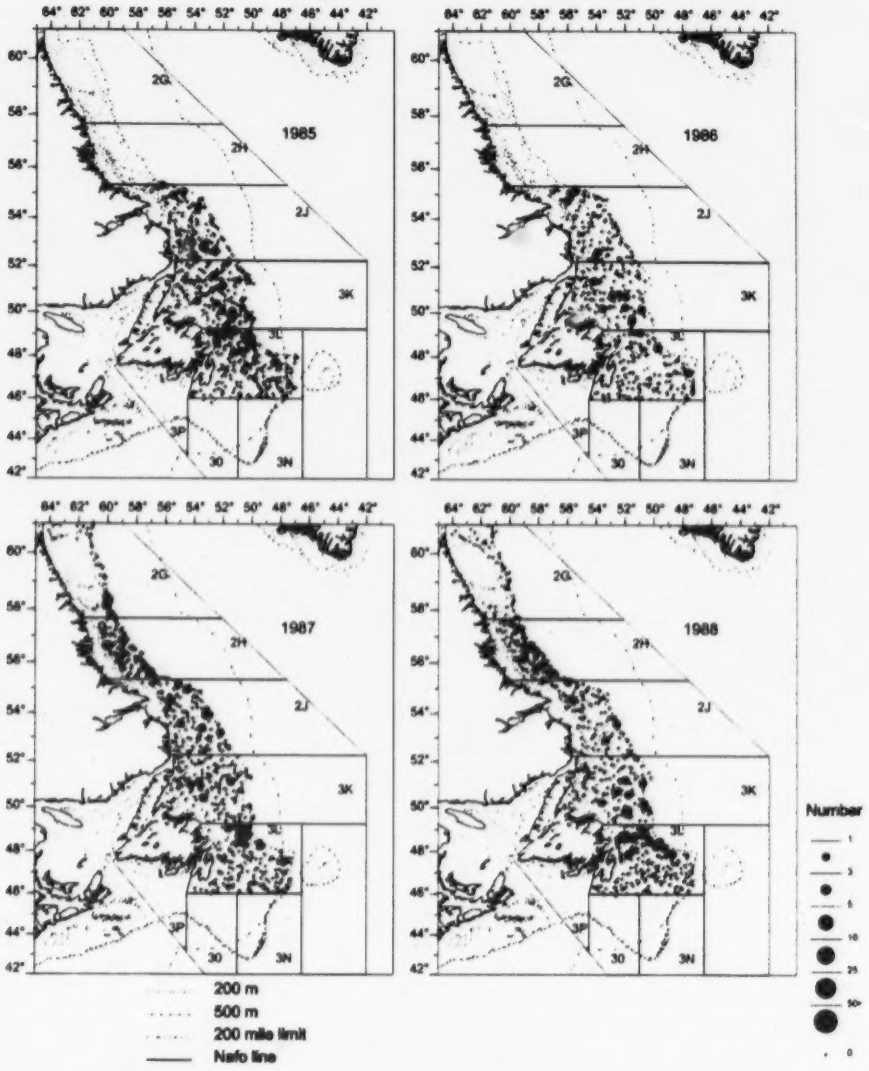

Figure 12b: Distribution of spotted wolffish LESS THAN 55cm in length captured in fall DFO surveys, 1985-1988.

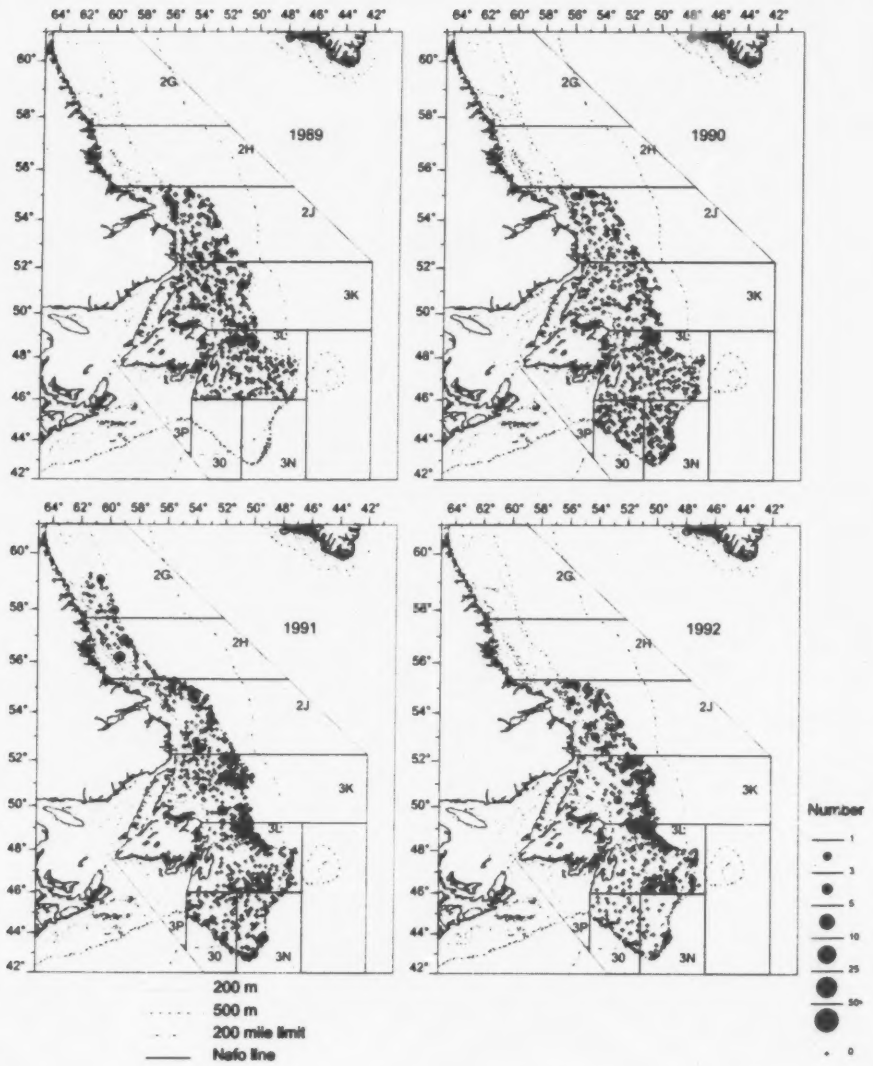

Figure 12c: Distribution of spotted wolffish LESS THAN 55cm in length captured in fall DFO surveys, 1989-1992.

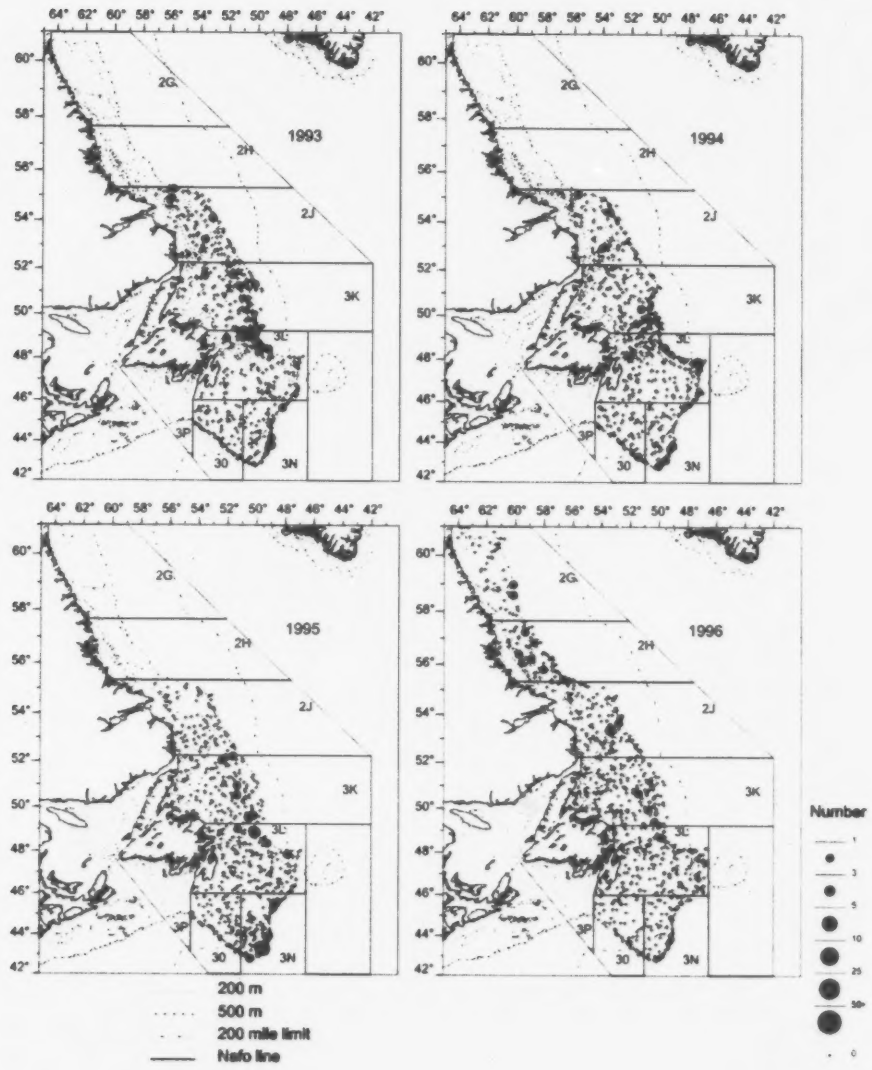

Figure 12d: Distribution of spotted wolffish LESS THAN 55cm in length captured in fall DFO surveys, 1993-1996.

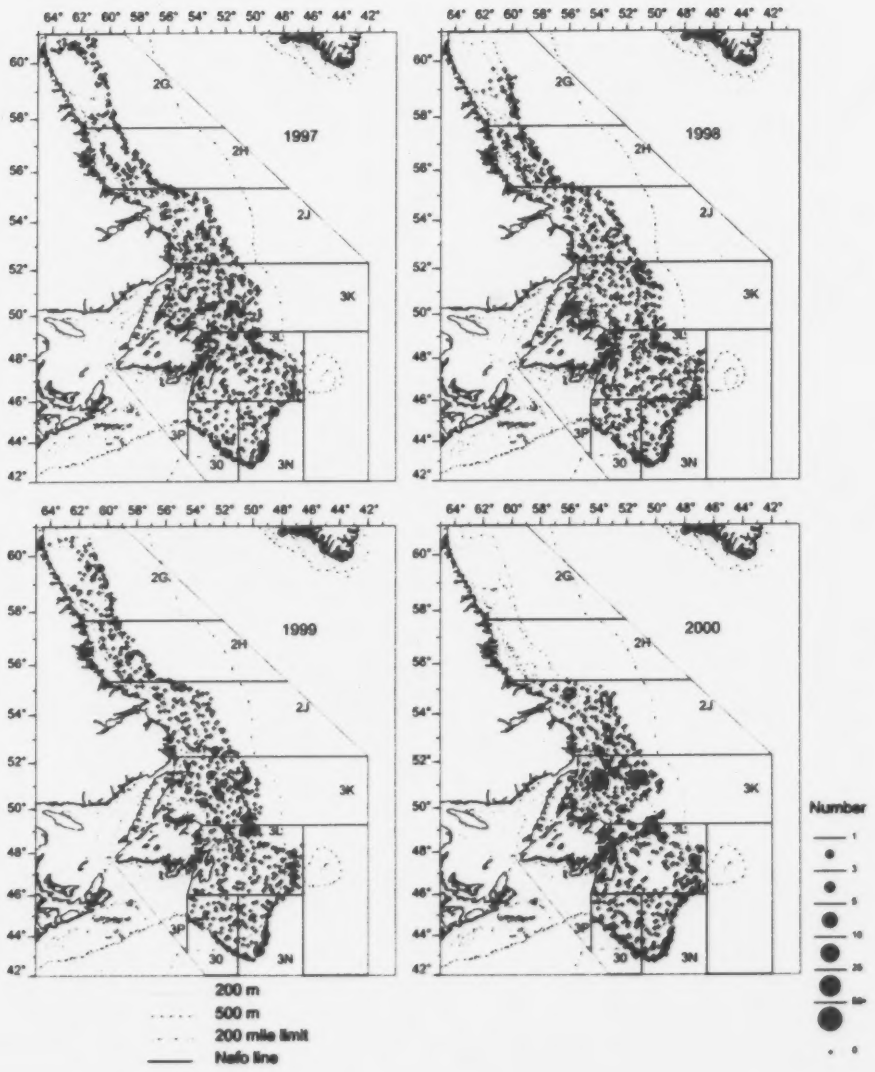

Figure 12e: Distribution of spotted wolffish LESS THAN 55cm in length captured in fall DFO surveys, 1997-2000.

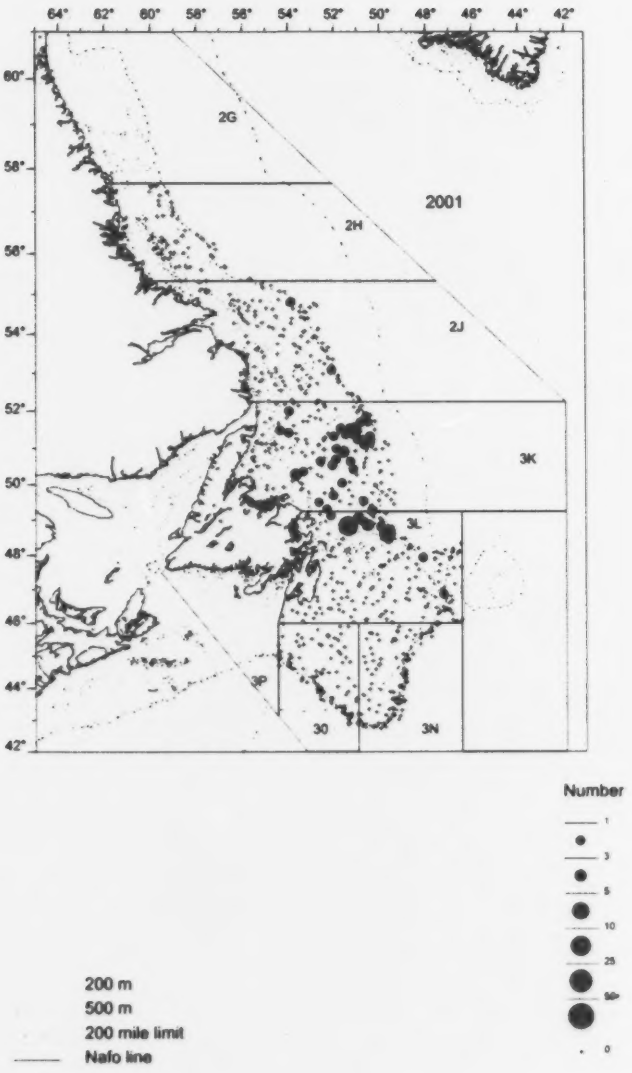

Figure 12f: Distribution of spotted wolffish LESS THAN 55cm in length captured in fall DFO surveys, 2001

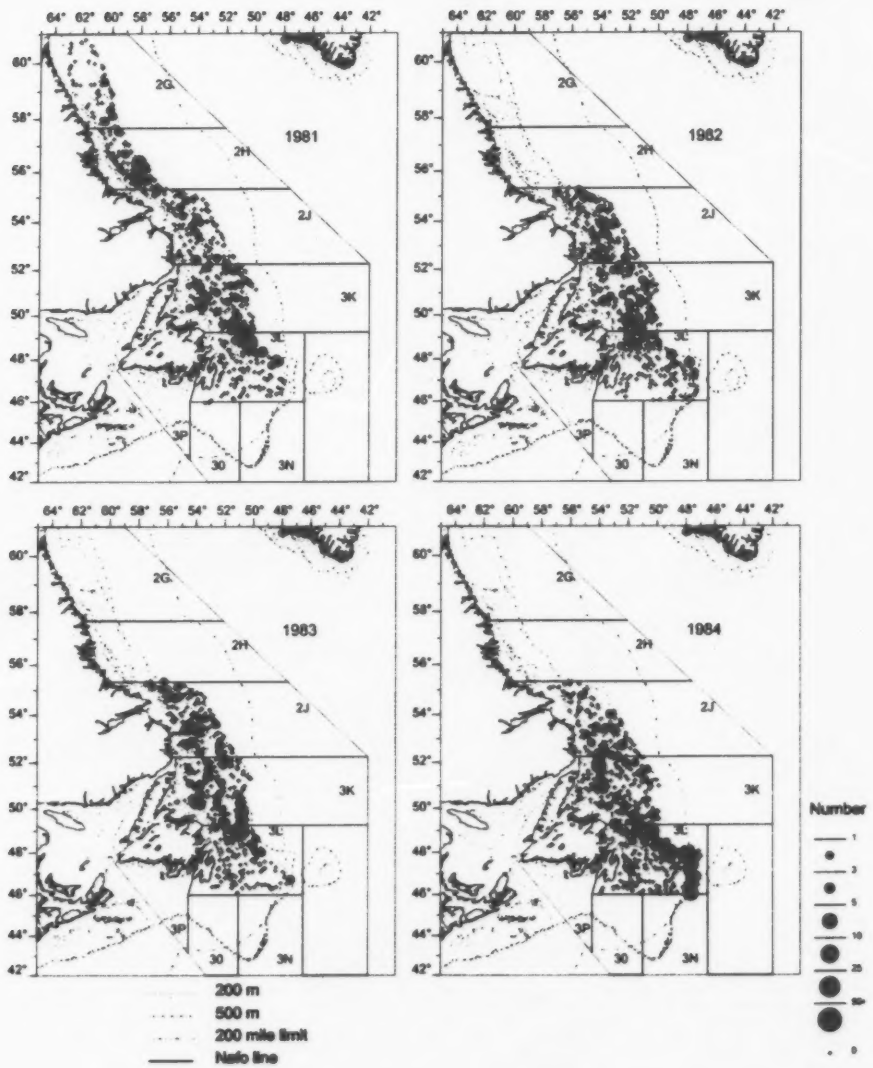

Figure 13a: Distribution of striped wolffish GREATER than 55cm in length captured in fall DFO surveys, 1981-1984.

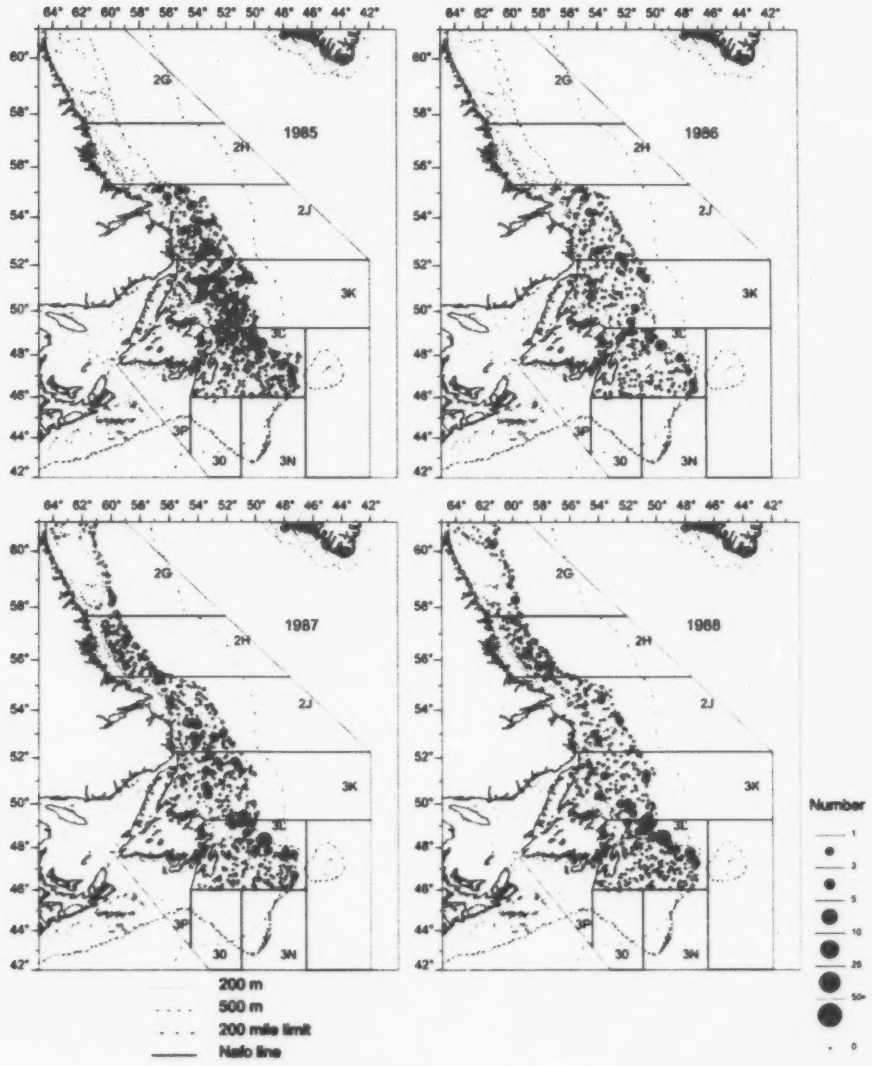

Figure 13b: Distribution of striped wolffish GREATER than 55cm in length captured in fall DFO surveys, 1985-1988.

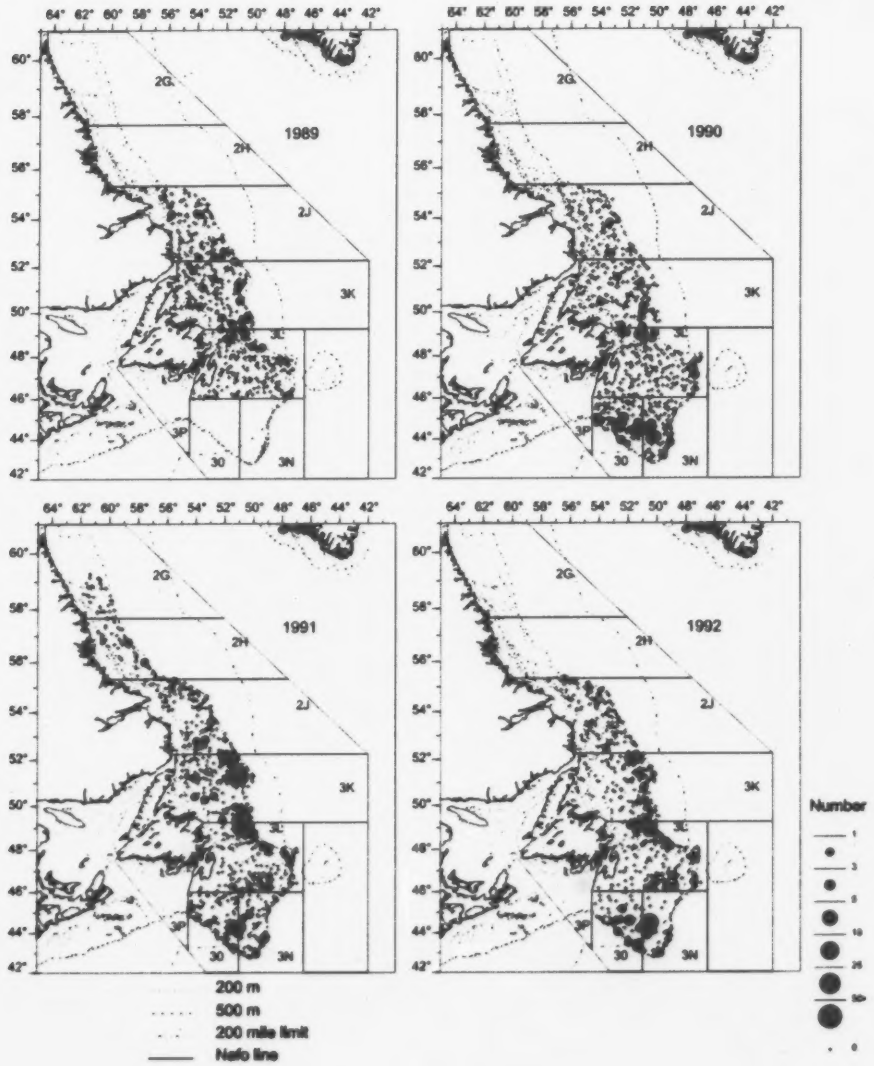

Figure 13c: Distribution of striped wolffish GREATER than 55cm in length captured in fall DFO surveys, 1989-1992.

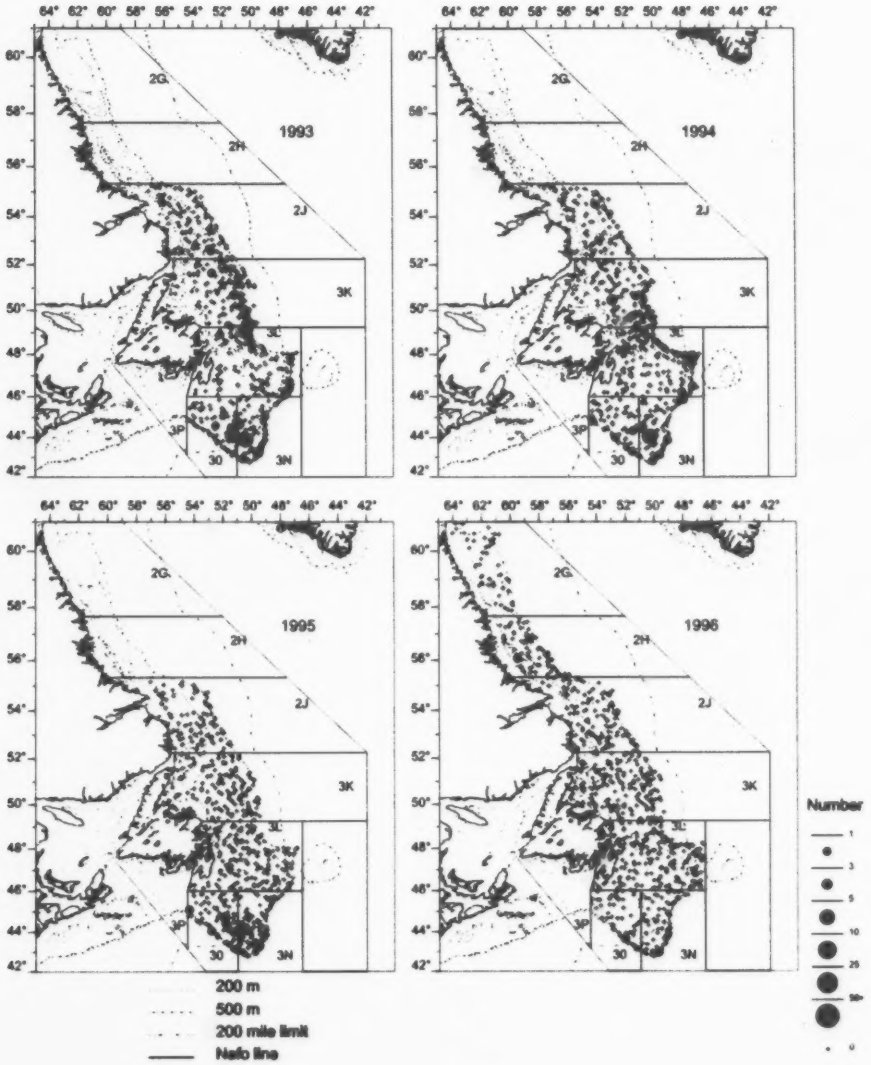

Figure 13d: Distribution of striped wolffish GREATER than 55cm in length captured in fall DFO surveys, 1993-1996.

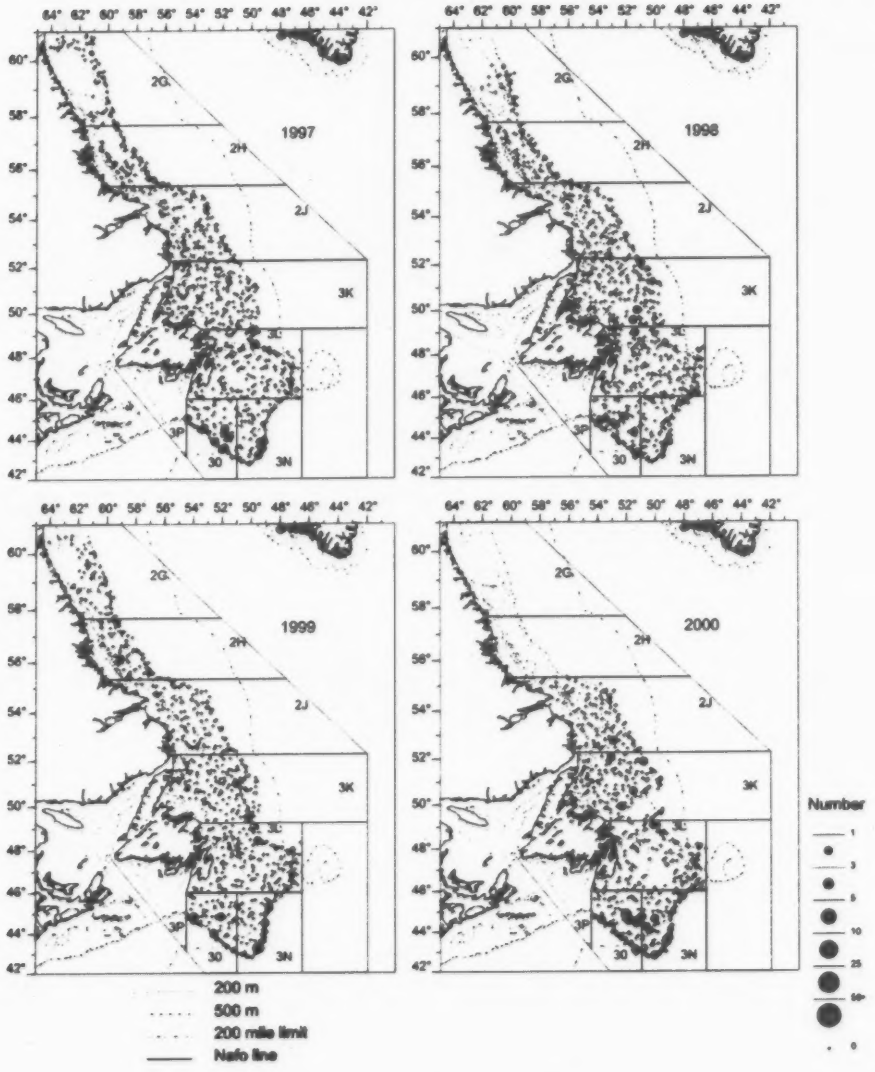

Figure 13e: Distribution of striped wolffish GREATER than 55cm in length captured in fall DFO surveys, 1997-2000.

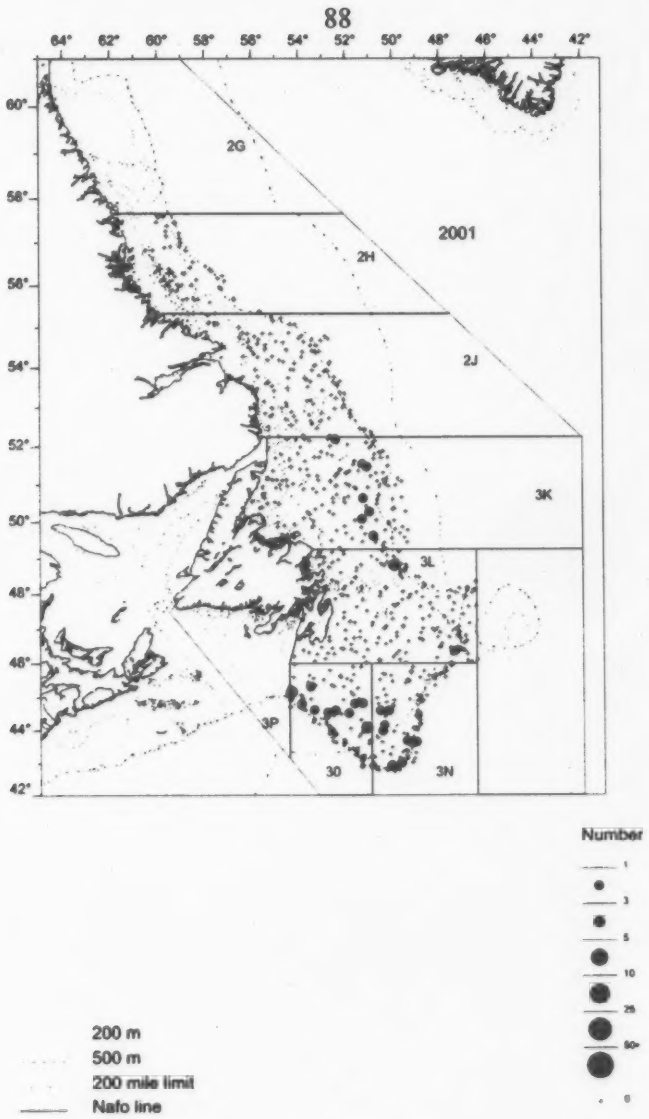

Figure 13f: Distribution of striped wolffish GREATER than 55cm in length captured in fall DFO surveys, 2001.

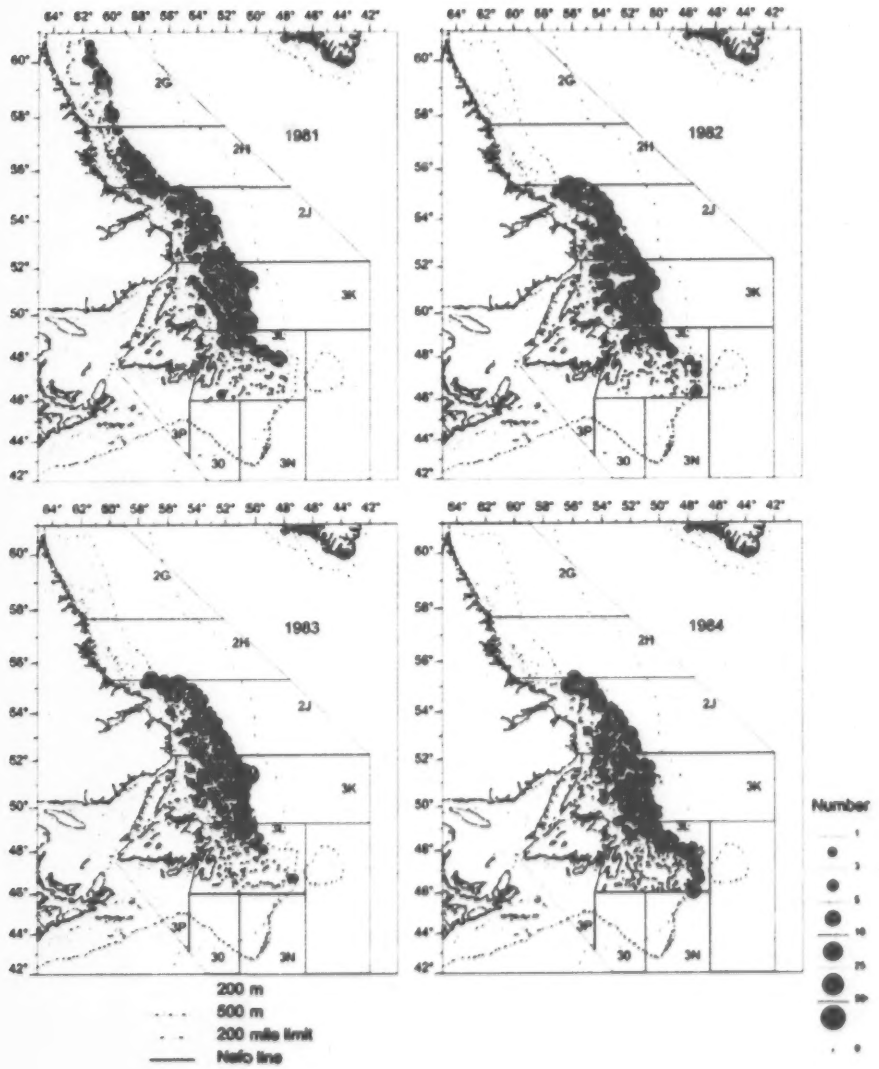

Figure 14a: Distribution of striped wolffish LESS THAN 55cm in length captured in fall DFO surveys, 1981-1984.

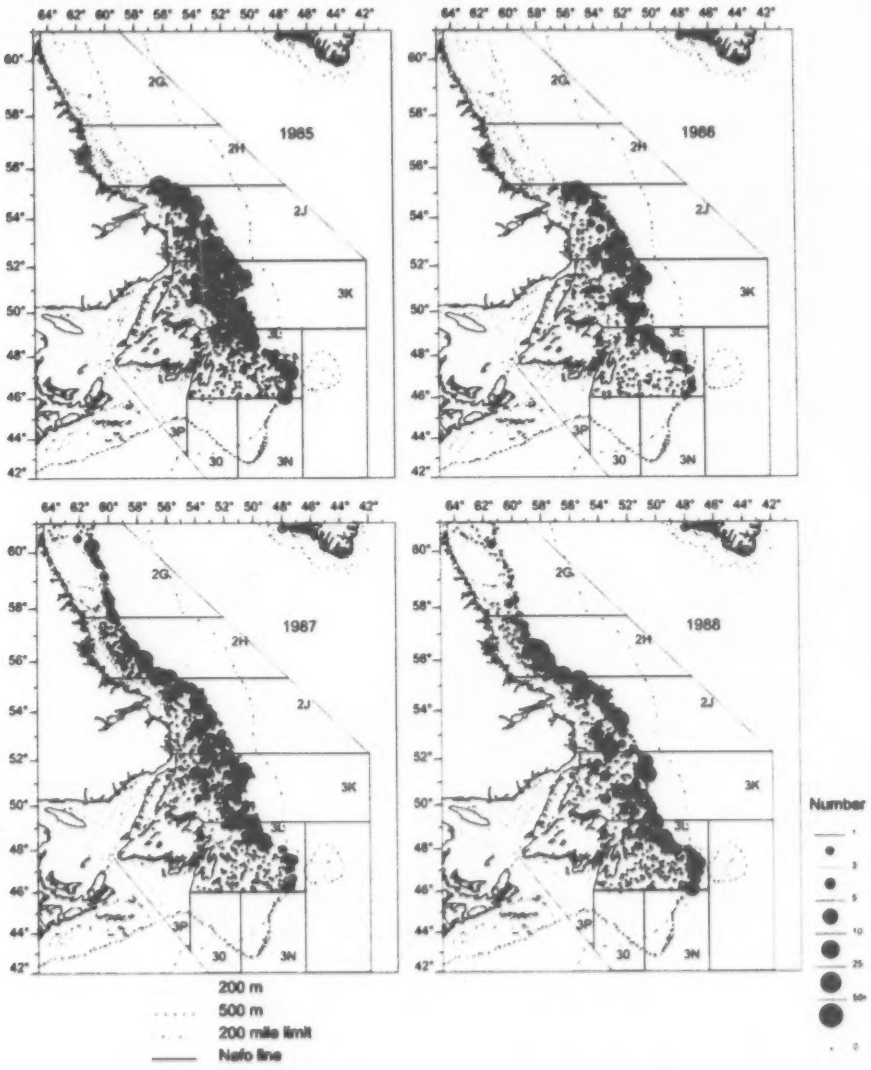

Figure 14b: Distribution of striped wolffish LESS THAN 55cm in length captured in fall DFO surveys, 1985-1988.

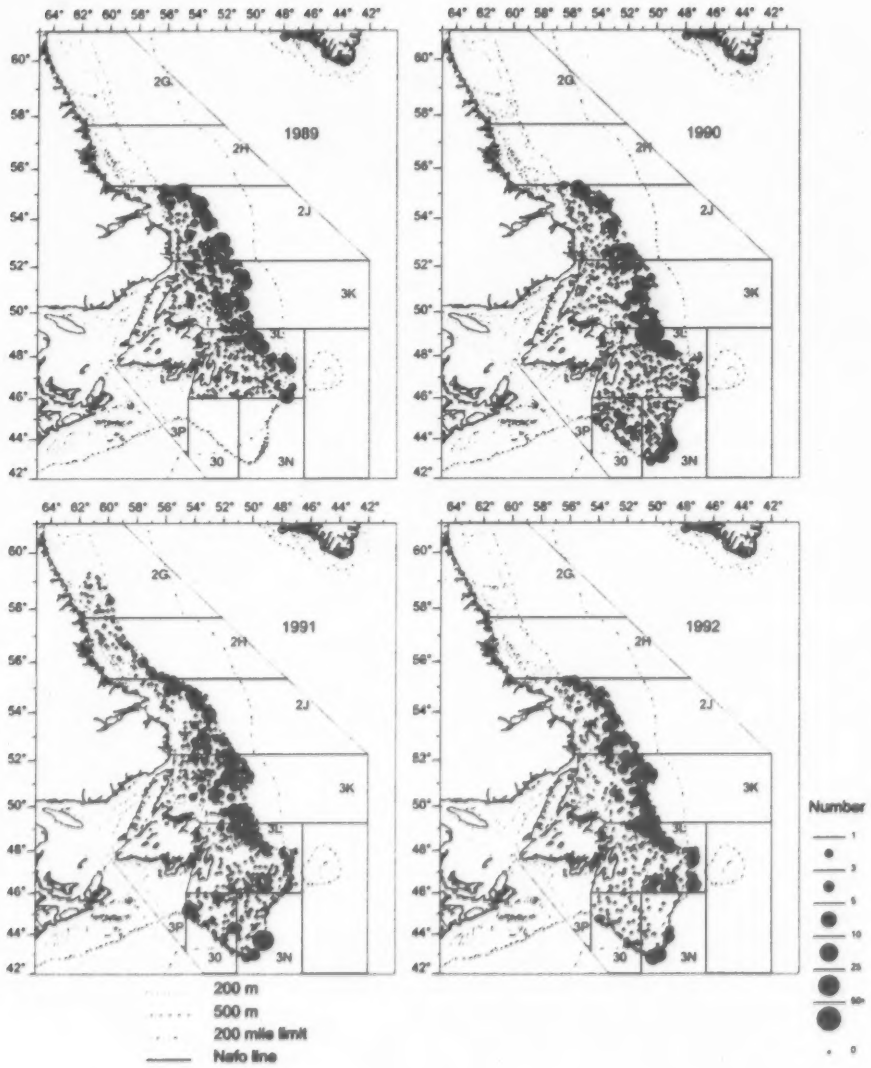

Figure 14c: Distribution of striped wolffish LESS THAN 55cm in length captured in fall DFO surveys, 1989-1992.

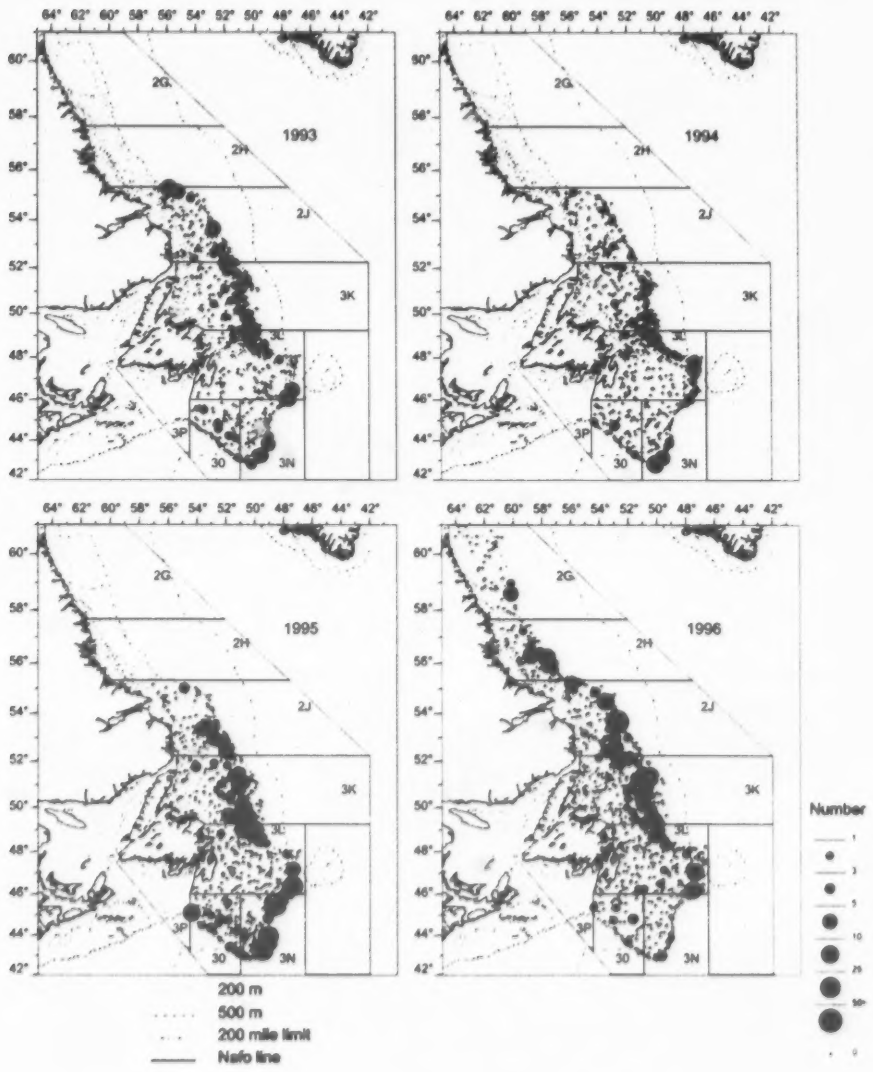

Figure 14d: Distribution of striped wolffish LESS THAN 55cm in length captured in fall DFO surveys, 1993-1996.

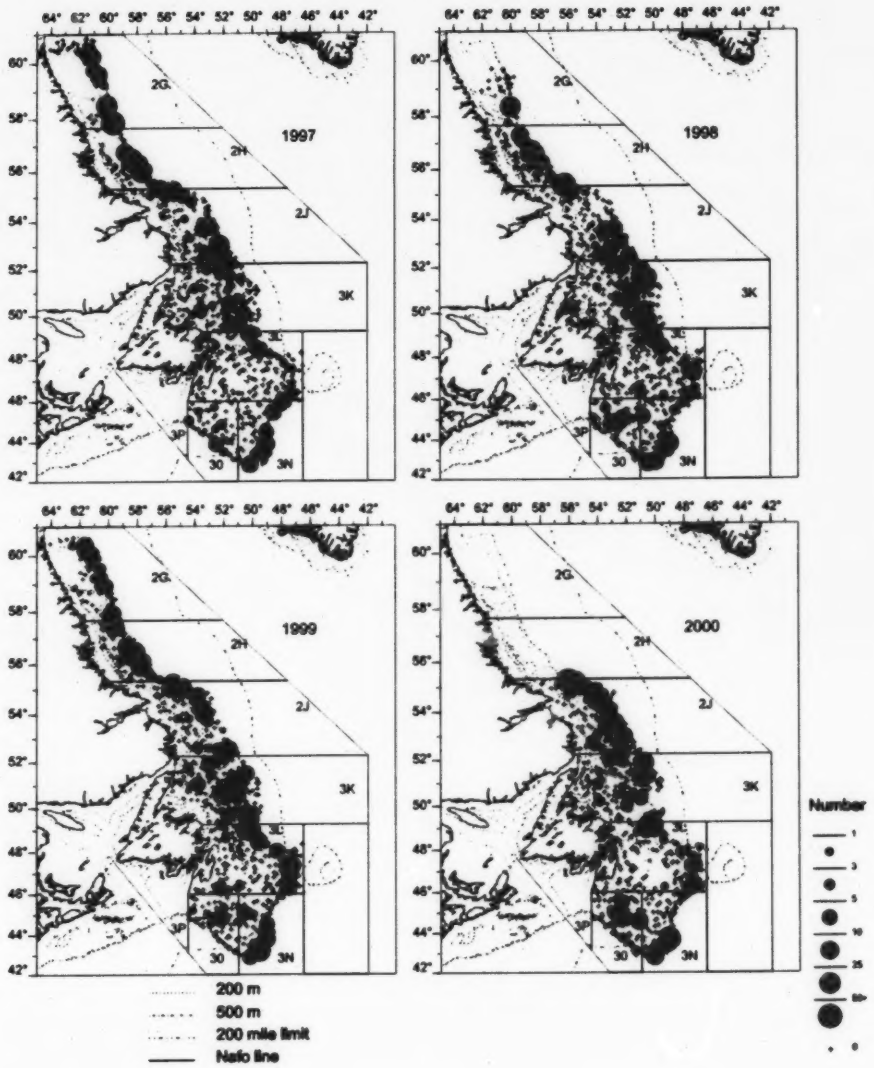

Figure 14e: Distribution of striped wolffish LESS THAN 55cm in length captured in fall DFO surveys, 1997-2000.

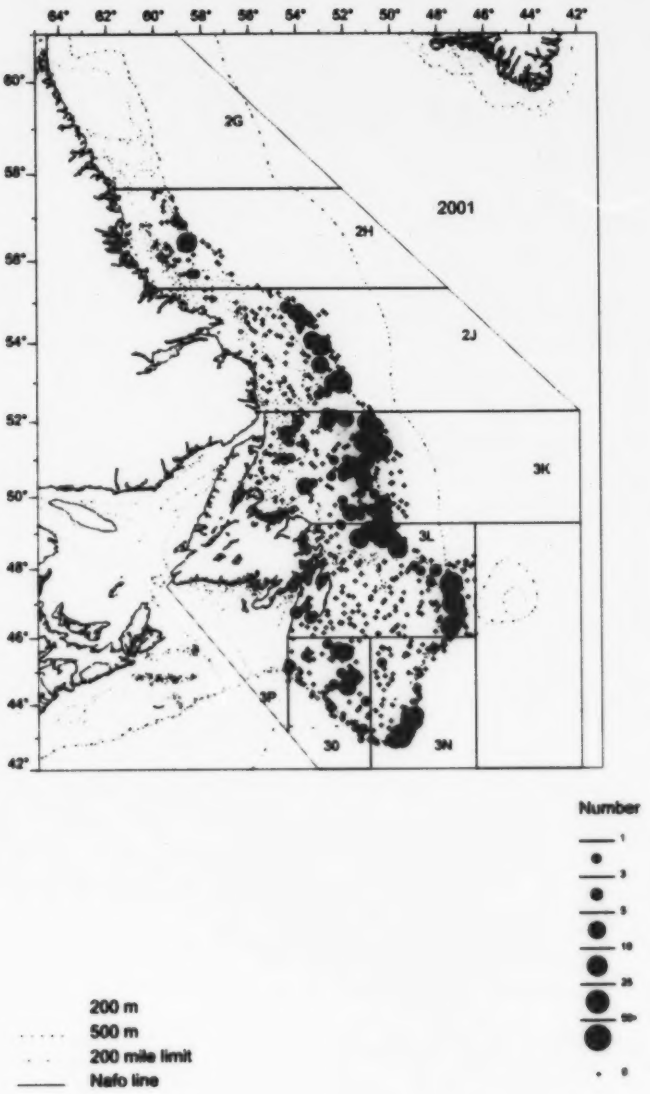

Figure 14f: Distribution of spotted wolffish LESS THAN 55cm in length captured in fall DFO surveys, 2001.

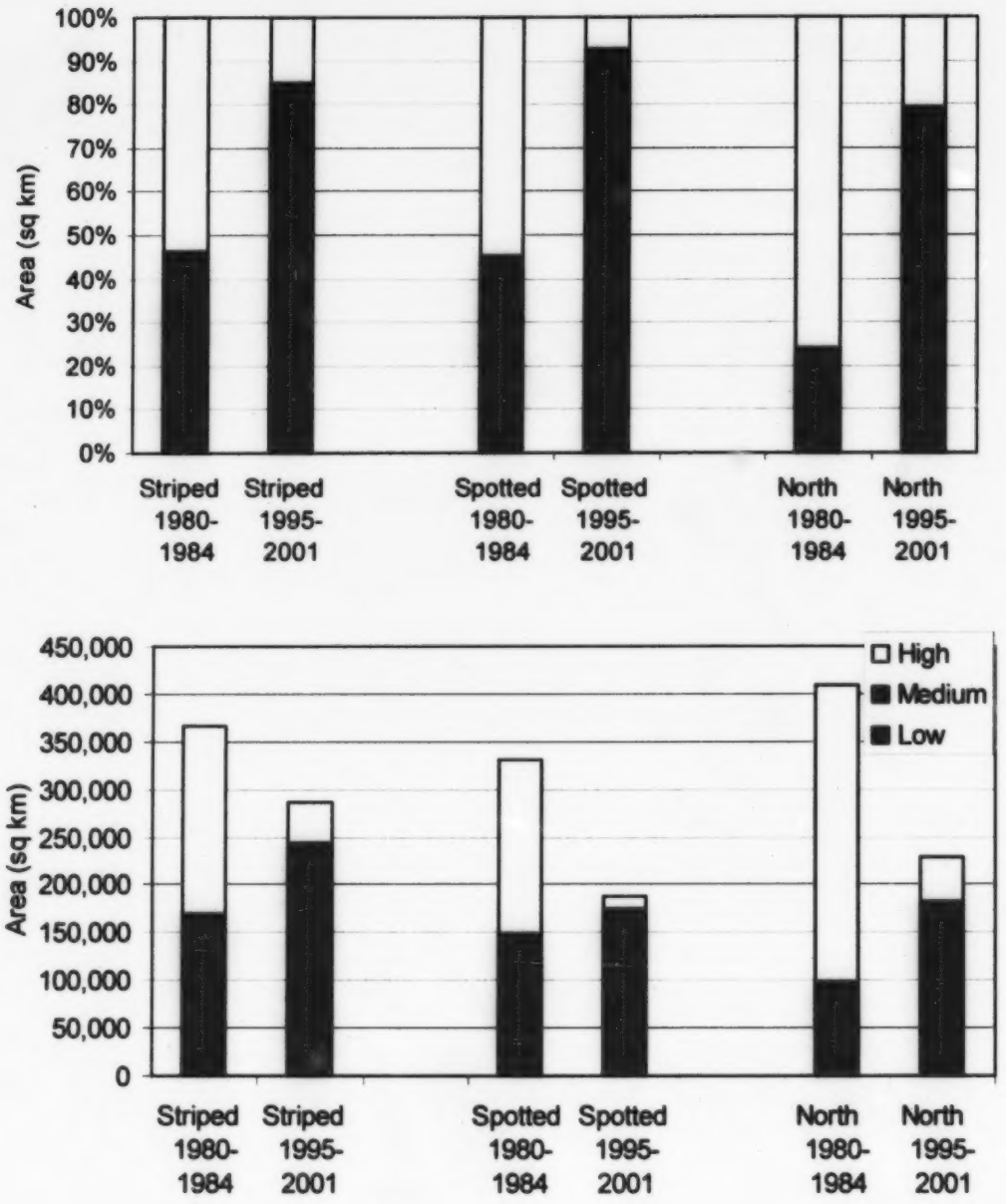

Figure 15. Relative and absolute area occupied by wolffish in NAFO division 2G-3P during 1980-84 and 1995-2001.

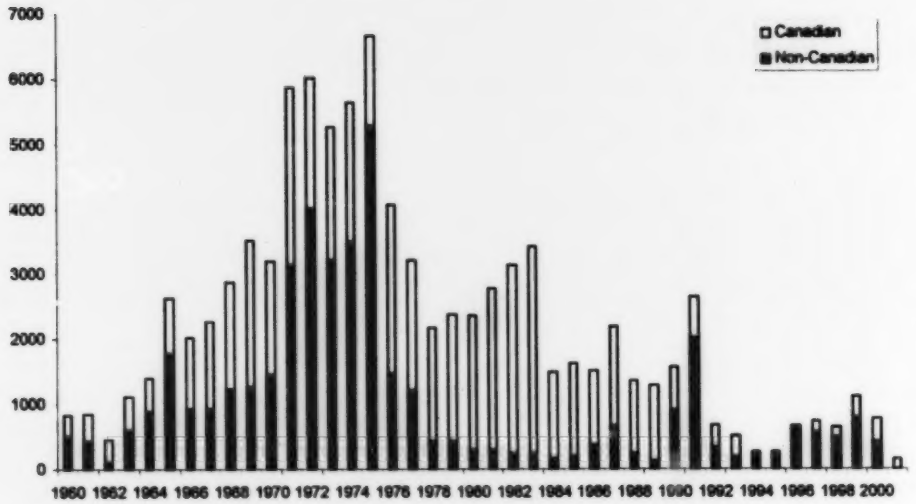

Figure 16a: Wolffish landings as reported by NAFO. Canadian landings from 1985-2001 are from the Zonal Interchange Format(ZIF) data. ZIF data for 2000-01 are provisional.

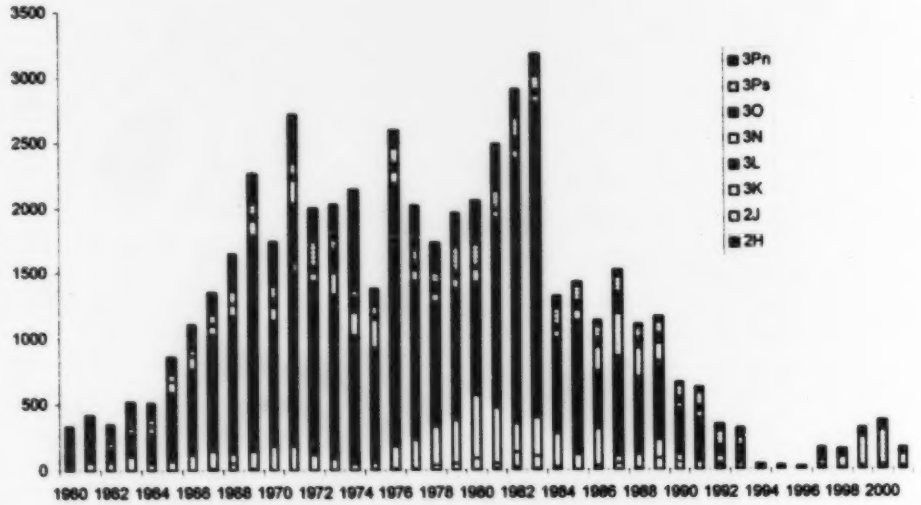

Figure 16b: Canadian wolffish landings by division. Data from 1985 are from the ZIF data (2000, 2001 are provisional).